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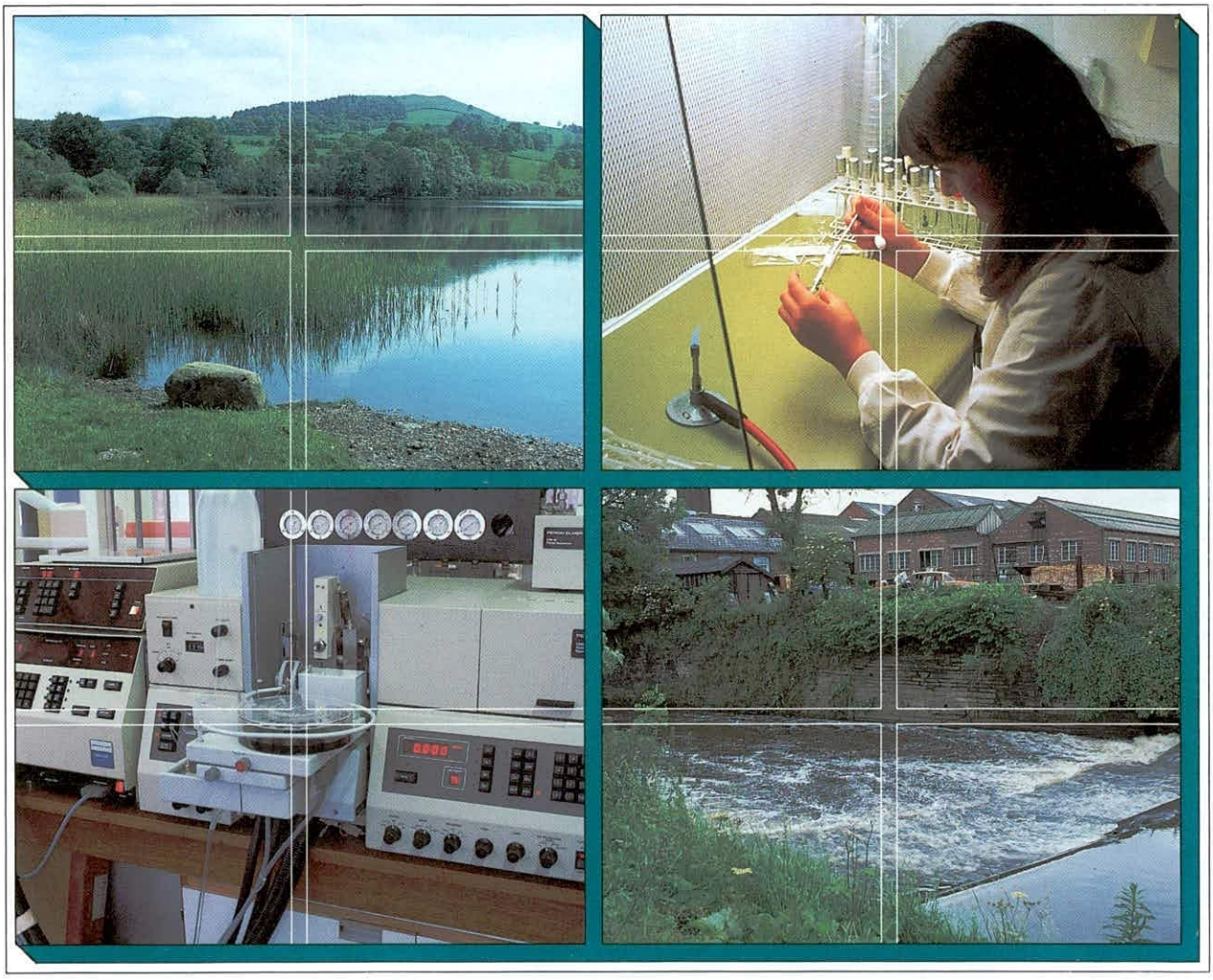
Institute of Freshwater Ecology

WATER QUALITY AT THE PROPOSED SOUTH EAST WATER ABSTRACTION AT POSTERN LANE, TONBRIDGE

J Hilton
J T Smith

Report To: South East Water
Project No: T04058L1
IFE Report Ref.No: RL/T04058L1/1



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This report makes its recommendations from a state of the art understanding of the way in which aquatic systems work and is considered to represent the best advice available at the present time. However, it should be borne in mind that changes in the physical and chemical properties of water are driven by a complex interaction of biological, chemical and physical processes which are still not entirely predictable and the Institute cannot guarantee that changes will occur exactly as predicted.

EXECUTIVE SUMMARY

South East Water have applied for a licence to abstract water for potable supply at Postern Lane, Tonbridge. The NRA suggested that there may be problems with quality at low flows.

Chemical analyses for the site at Hartlake on the river Medway have been plotted against flow. The resulting concentration distributions have been compared with guideline and mandatory water quality standards for water abstracted for drinking.

Although rare infringements of mandatory levels occurred for some determinands only ortho-phosphate, simazine and atrazine regularly exceeded mandatory limits. No evidence was found to substantiate the NRA's statement that water quality would be poor at low flows.

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INTRODUCTION

South East Water (SEW) has predicted that they will have a shortfall of water resources in the near future. As a result they have made applications for a number of new or increased abstraction licences. One of these is at Postern Lane, Tonbridge. In response to this application the National Rivers Authority (NRA) requested more information. In particular they stated that an assessment they had made suggested that, at low flows, the quality of the abstracted water would be such that SEW would have difficulty in meeting the required drinking water quality standards. The Institute of Freshwater Ecology (IFE) were commissioned to carry out an assessment of available data to clarify the position and identify potential problems.

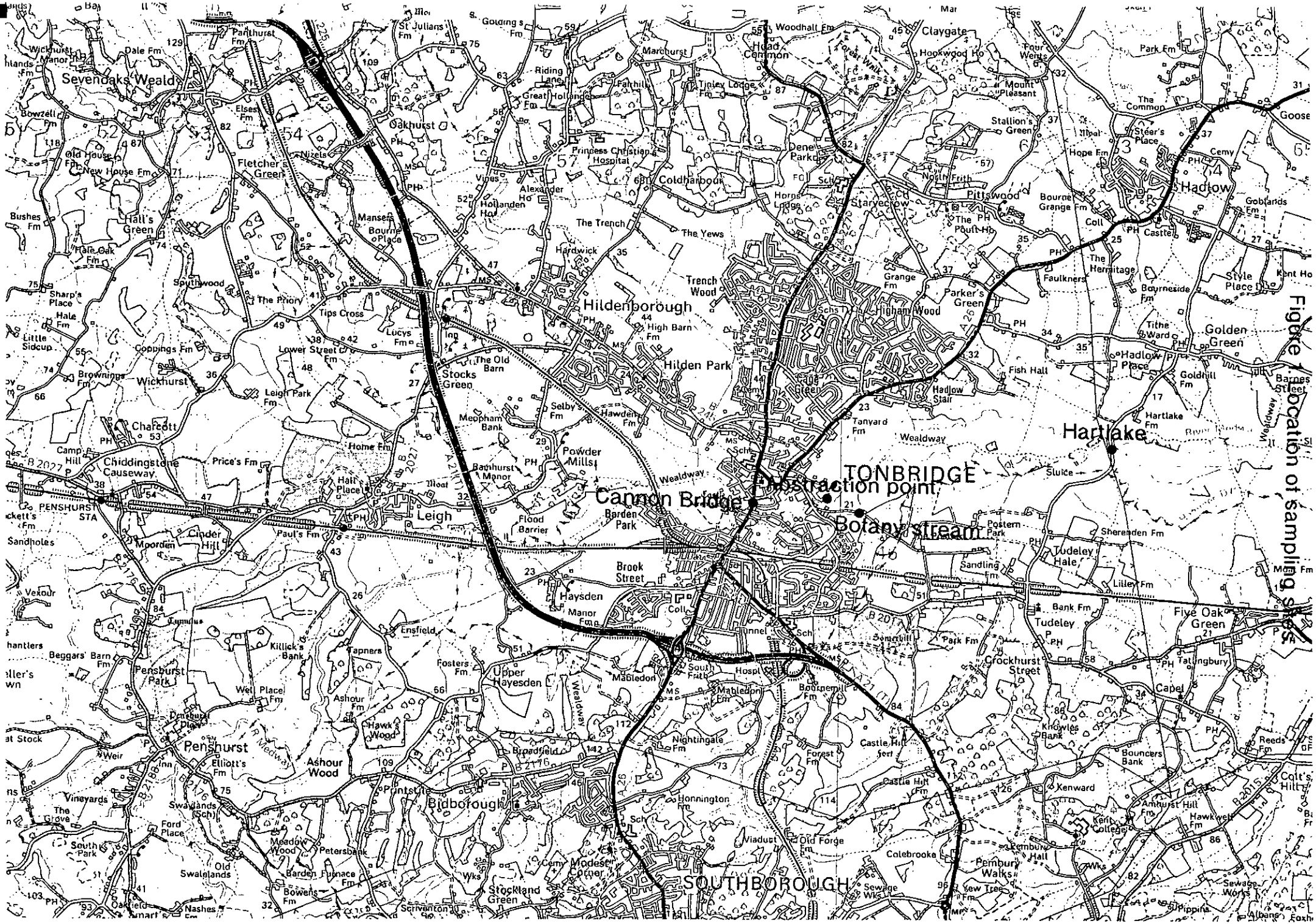
METHODS

The river system in the region of the proposed abstraction is shown in Figure 1. The proposed abstraction (Grid reference, TQ 5987 4654) is on the river Medway, in the town of Tonbridge. A few miles upstream the river splits into two channels which join together again below the abstraction point. The NRA regularly sample at three sites in the region: Cannon bridge (TQ 597 465) which is immediately upstream of the split into two channels; Botany stream (TQ 602 465) which is down stream of the sewage works which discharges into the second channel, i.e. not the channel on which the abstraction will be located; Hartlake (TQ 629 472) which is downstream of the confluence of the two channels.

Exploratory data for the three sites were obtained from the NRA. At this point it was agreed with the client that the water quality at the Cannon Bridge site was probably the most representative of the water at the abstraction site, since, both of the other two sites would contain sewage effluent and, hence be of lower quality than the abstraction site. However, further discussion with the NRA revealed that a full analysis suite for compliance with water abstraction requirements was only carried out at Hartlake. The other sites only had a very reduced set of analytical determinands (Temperature, dissolved oxygen, BOD-ATU, Ammonia, Nitrate, ortho-phosphate, chloride). As a result it was decided to carry out a detailed analysis of the Hartlake data on the basis that compliance with the requirements at this site would confirm compliance at the abstraction point, since at Hartlake, treated sewage had been discharged in to the river. Non-compliance would be investigated further using any other available data.

The NRA were unable to supply the data on disc. Only printed, hard copy was available. The pages of data were read through a scanner and transformed into ascii files using the software package Omnipage. A FORTRAN program was written in house to identify the different determinands on the basis of their analysis code and transfer data for each determinand to a separate file.

Flow data were supplied by the Institute of Hydrology. Flows at Hartlake were estimated as Chafford weir + Penhurst times 1.1 to allow for catchment area differences. These data were supplied as an ASCII file containing daily flows in sequence for each year of interest which was read into an EXCEL spreadsheet file and assigned individual (daily) dates then output again to an ASCII file. This file was then accessed by the FORTRAN programme to identify the appropriate daily flow for each sample date. The appropriate daily flow was stored with each determinand in the determinand's data file. The flow data were from April 1988 to March 1994, whereas the chemical data were from May 1990 to February 1995. As a result only the overlapping period, May 1990 to March 1994 were used in further analysis.


Sevenoaks Weald
Hildenborough
Leigh
Penshurst
Bidborough
SOUTHBOROUGH
TONBRIDGE
Hartlake
Hadlow
Cannon Bridge
Obstraction point
Botany stream
Five Oak Green
Golden Green
Pittswood
Claygate
Chiddingstone Causeway
Chafcott
Penshurst Park
Ashour Wood
Upper Hayesden
Brook Street
Tudeley
Tudeley Hale
Grockhurst Street
Capel
Hadlow Place
Hadlow Stair
Fish Hall
Tanyard Fm
Wealdway
Flood Barrier
Barden Park
Powder Mills
Haysden Manor Fm
Mabledon
Nightingale Fm
Castle Hill
Honnington Fm
Stockland Green
Scriventon
Colebrooke
Pembury Walks
Kent College
Figure 1. Location of sampling sites.

RESULTS

The log of concentration was plotted against the log of flow for all determinands for which sufficient data were available. The graphs are shown in the Appendix 1. A number of determinands showed no or very few values above the limit of detection. These data are recorded in Table 1.

The quality standard for abstracted water

The statutory requirements for surface water intended for drinking are laid out in the European Community Council Directive number 75/4400/EEC. The requirements are given in Table 2. They are enacted in UK law by a statute issued in 1989. Since full treatment will be available at the new plant, guidelines for treatment type A3 have been used for comparison. The EC directive on drinking water (80/778/EEC) gives two mandatory levels for pesticides, 0.5 ug l^{-1} total and 0.1 ug l^{-1} for individual pesticides. These levels have recently been amended to the latter value only, i.e. the total value has been dropped. Where it is deemed relevant, prescribed values from The Water Supply (Water Quality) Regulations 1989 have been used as guidelines. In all cases the EC directive has been given precedence. Prescribed values have only been used as guidelines when the determinand is not altered by normal water treatment process. On such occasions the use of prescribed values will be noted. Compliance of the water quality with these standards is discussed below.

Physical determinands

Temperature - all measured values are at or below the guideline of 22°C. No temperatures approach the mandatory levels.
Conductivity - shows an increasing value at lower flows but all measured values are considerably below the guideline value of 1000uS cm^{-1}.
Suspended solids - no mandatory or guideline values are published for suspended solids when full treatment is available.
Colour - at all flow rates a proportion of the data exceed the guideline value of 50 mg l^{-1}. At high flows, mainly above 10 cumec, a few measurements exceed the mandatory reference level.
Turbidity - no mandatory or guideline values are published for turbidity.

Table 1. Determinands with too few data points to plot. <LoD = less than limit of detection.

Determinand	Maximum	Notes
Total Mercury	0.216 µg/l Hg	Most values < LoD.
Total Cadmium	0.5 µg/l Cd	Most values < LoD
Total Oxidised N	18.5 mg/l N	Single measurement
Free Cyanide	< 0.01 mg/l	Single measurement < LoD
Total Cyanide	0.05 mg/l CN	All < or close to DL
Total Phenols	0.02 mg/l	Most < LoD. Guideline limit 0.1 mg/l
Pentachlorophen	100 ng/l	All but one < LoD
Total Silver	< 1 µg/l	All < LoD
Total Selenium	< 1 µg/l	All < LoD
HCH Alpha	14 ng/l	Most values < LoD
Heptachlor	< 5ng/l	All < LoD
Aldrin	< 5 ng/l	All < LoD
Dieldrin	7 ng/l	All but one < LoD
DDE PP	10 ng/l	All but one < LoD
DDE PP (TDE PP)	< 5 ng/l	All < LoD
DDT PP	< 5 ng/l	All < LoD
Endrin	< 5ng/l	All < LoD
Carbon Tetrachlor	0.018 µg/l	All but one < LoD
Isodrin	< 5 ng/l	All < LoD
HCH Epsilon	4 ng/l	All but one < LoD
Hexachlorobenzene	41ng/l	Most values < LoD
Hexachlorobutadiene	4 ng/l	Most values < LoD
HCH Beta	2 ng/l	All but one < LoD
HCH Delta	8 ng/l	Most values < LoD
DDT OP	8 ng/l	All but one < LoD
Prometryne	< 20 ng/l	All < LoD
Propazine	< 20 ng/l	All < LoD
Heptachlor Epoxide	< 5 ng/l	All < LoD
Parathion	< 20 ng/l	All < LoD
Carbophenothion	< 20 ng/l	All < LoD
Dimethoate	< 20 ng/l	All < LoD
Malathion	< 20 ng/l	All < LoD
Persist. Hydrocarb.	1.4 µg/l	All but one < LoD
O-P Pesticides	< 450 ng/l	All < LoD
Dichloroethane	0.12µg/l	All but one < LoD
Trichloroethylene	0.11µg/l	All but one < LoD
Tetrachloroethylene	0.06 µg/l	All but one < LoD
Phenols	3.4 µg/l	All but one < LoD
Azinphos-Methyl	< 20 ng/l	All < LoD
Fenitrothion	< 20 ng/l	All < LoD
Dichlorvos	25 ng/l	All but one < LoD
PCBs	< 5 ng/l	PCB - 28,52,101,118,138,153,180. All < LoD
1,2,3Trichlorobenz.	< 5 ng/l	All < LoD
1,2,4 Trichlorobenz.	< 5 ng/l	All < LoD
1,3,5 Trichlorobenz.	< 5 ng/l	All < LoD
Chlorophyll B	5µg/l	Most < LoD
Phaeophytin A	2.4 µg/l	Most < LoD
Phaeopytin B	1.9 µg/l	Most < LoD

Table 2. Characteristics of surface water intended for the abstraction of drinking water.

	Parameters		A1 G	A1 1	A2 G	A2 1	A3 G	A3 1
1	pH		6.5 to 8.5		5.5 to 9		5.5 to 9	
2	Coloration (after simple filtration)	mg/l Pt scale	10	20 (O)	50	100 (O)	50	200 (O)
3	Total suspended solids	mg/l SS	25					
4	Temperature	°C	22	25 (O)	22	25 (O)	22	25 (O)
5	Conductivity	µs/cm^{-1} at 20°C	1 000		1 000		1 000	
6	Odour	(dilution factor at 25°C)	3		10		20	
7*	Nitrates	mg/l NO_3	25	50 (O)		50 (O)		50 (O)
8(1)	Fluorides	mg/l F	0.7 to 1	1.5	0.7 to 1.7		0.7 to 1.7	
9	Total extractable organic chlorine	mg/l Cl						
10*	Dissolved iron	mg/l Fe	0.1	0.3	1	2	1	
11*	Manganese	mg/l Mn	0.05		0.1		1	
12	Copper	mg/l Cu	0.02	0.05 (O)	0.05		1	
13	Zinc	mg/l Zn	0.5	3	1	5	1	5
14	Boron	mg/l B	1		1		1	
15	Beryllium	mg/l Be						
16	Cobalt	mg/l Co						
17	Nickel	mg/l Ni						
18	Vanadium	mg/l V						
19	Arsenic	mg/l As	0.01	0.05		0.05	0.05	0.1
20	Cadmium	mg/l Cd	0.001	0.005	0.001	0.005	0.001	0.005
21	Total chromium	mg/l Cr		0.05		0.05		0.05
22	Lead	mg/l Pb		0.05		0.05		0.05
23	Selenium	mg/l Se		0.01		0.01		0.01
24	Mercury	mg/l Hg	0.0005	0.001	0.0005	0.001	0.0005	0.001
25	Barium	mg/l Ba		0.1		1		1
26	Cyanide	mg/l Cn		0.05		0.05		0.05

	Parameters		A1 G	A1 1	A2 G	A2 1	A3 G	A3 1
27	Sulphates	mg/l SO_4	150	250	150	250 (O)	150	250 (O)
28	Chlorides	mg/l Cl	200		200		200	
29	Surfactants (reacting with methyl blue)	mg/l (laurelsulphate)	0.2		0.2		0.5	
30*(2)	Phosphates	mg/l P_4O_3	0.4		0.7		0.7	
31	Phenols (phenol index) paranitraniline 4 aminoantipyrine	mg/l C_4H_3OH		0.001	0.001	0.005	0.01	0.1
32	Dissolved or emulsified hydrocarbons (after extraction by petroleum ether)	mg/l		0.05		0.2	0.5	1
33	Polycyclic aromatic hydrocarbons	mg/l		0.0002		0.0002		0.001
34	Total pesticides (parathion, BHC, dieldrin)	mg/l		0.001		0.0025		0.005
35*	Chemical oxygen demand (COD)	mg/l O_2					30	
36*	Dissolved oxygen saturation rate	% O_2	> 70		> 50		> 30	
37*	Biochemical oxygen demand (BOD) (at 20°C without nitrification)	mg/l O_2	< 3		< 5		< 7	
38	Nitrogen by Kjeldahl method (except NO_3)	mg/l N	1		2		3	
39	Ammonia	mg/l NH_4	0.05		1	1.5	2	4 (O)
40	Substances extractable with chloroform	mg/l SEC	0.1		0.2		0.5	
41	Total organic carbon	mg/l C						
42	Residual organic carbon after flocculation and membrane filtration (5 µ) TOC	mg/l C						
43	Total coliforms 37°C	/100 ml	50		5 000		50 000	
44	Faecal coliforms	/100 ml	20		2 000		20 000	
45	Faecal streptococci	/100 ml	20		1 000		10 000	
46	Salmonella		Not present in 5 000 ml		Not present in 1 000 ml			

I = mandatory
O = exceptional climatic or geographical conditions
G = guide
* = see Article 8 (d)

Major ions

pH - one measurement out of 19 falls above the maximum guideline value of 9. There are no mandatory levels.
Sodium - shows a significant reduction with flow indicating that a point source, possibly sewage treatment, is a major contributor. There are no guideline or mandatory levels for sodium. All values are below the prescribed value of 150 mg l^{-1}.
Potassium - is approximately constant, irrespective of flow rate. There are no guideline or mandatory levels for potassium. Concentrations are on or just below the prescribed level of 12 mg l^{-1}.
Calcium - one data point appears to have been wrongly recorde d in the original. Concentrations are effectively constant with flow. There are no guideline or mandatory levels for calcium. Concentrations are well below the prescribed level of 250 mg l^{-1}.
Magnesium - shows a slight decrease with increasing flow. There are no guideline or mandatory levels for magnesium. Concentrations are about an order of magnitude below the prescribed level of 50 mg l^{-1}.
Hardness - is a combination of calcium and magnesium concentrations. It shows a significant reduction in concentration with flow. This is unusual as the dominant ion, Ca, shows no relationship with flow. There are no guideline or mandatory levels for hardness. Concentrations are all greater than the prescribed minimum concentration of 100 mg l^{-1} as $CaCO_3$.
Chloride - shows a significant decrease with increasing flow suggesting the same source as sodium. All measured values are well below the guideline value of 200 mg l^{-1} and the prescribed guideline of 150 mg l^{-1}.
Sulphate - is approximately constant with changing flows. All measured values are well below the guideline levels of 150 mg l^{-1}.
Alkalinity - shows a significant decrease with increasing flows. There are no guideline or mandatory levels for alkalinity. At flows greater than about 10 cumec, alkalinity levels can fall below the prescribed minimum of 49 mg l^{-1} as $CaCO_3$.

Organic pollution

Dissolved oxygen - tend to be much lower at low flows but all measured values are significantly greater than the guideline minimum of 30 % saturation.
BOD - values are very scattered, ranging from 1 to 6.8 mg l^{-1}. However all values are below the guideline figure of 7 mg l^{-1}.
COD - 6 out of 16 COD results exceed the guideline level of 30 mg^{-1}. However there is no mandatory level for COD.
Organic carbon - most concentrations are below 10 mg l^{-1}. There are no guideline or mandatory levels for organic carbon.
Nitrogen Kjeldahl - three out of thirteen concentrations are greater than the guideline value of 3 mg l^{-1}. There is no mandatory figure. All values are greater than the prescribed level of 1 mg l^{-1} but levels will be reduced during treatment.

Nutrients

Ammonia - there is no relationship with flow. All values except one are below the guideline value of 1.6 mg l^{-1} as N (= 2 mg l^{-1} as NH_4). All values are well below the mandatory value of 3.1 mg l^{-1} as N (= 4 mg l^{-1} as NH_4).

Nitrate - All measured concentrations, except two, are below the mandatory limit of 12 mg l^{-1} (50 mg l^{-1} NO_3). The two exceptional values are so far from the rest that they may be mis transfers of concentrations in the original data. Conversely they may indicate occasional very high spike concentrations, from an unknown source.
Nitrite - There are no guideline or mandatory levels for nitrite. The majority of values are less than 0.1 mg l^{-1} prescribed value and nitrite will improve significantly during treatment.
Phosphate (Total) - shows a significant negative relationship with flow. Comparison with the ortho-phosphate data suggests that most of the total phosphate is in the form of ortho-phosphate. There are no guideline or mandatory levels for total phosphorus.
Ortho-phosphate - like total phosphorus, ortho-phosphorus shows a negative relationship with flow which suggests sewage treatment works as the source. All values are greater than the guideline value of 0.3 mg l^{-1} as P (=0.7 mg l^{-1} as P_2O_3). This parameter has no intrinsic health effect. It is included purely to reduce the likelihood of algal growth if the water is stored in a reservoir for significant periods of time. Since, in this case, no storage is envisaged the high values for this parameter are not relevant. All values greater than the prescribed level of 2200 ug l^{-1}.
Silicate - remans constant at about 10 mg l^{-1}. There are no guideline or mandatory levels for silicate.
Chlorophyll a -range over two orders of magnitude. Highest values were found at low flows. There are no guideline or mandatory levels for chlorophyll a.
Total chlorophyll - this includes chlorophyll breakdown products as well as chlorophyll a. Values range from about o.2 to 100 mg l^{-1}. There is no relationship with flow. There are no guideline or mandatory levels for total chlorophyll.
Total phaeophytins - the range of values is similar to those for total chlorophyll suggesting that much of the latter is due to degraded chlorophylls. There are no guideline or mandatory levels for total phaeophytins.

Trace elements

Fluoride - is generally less than 0.2 mg l^{-1}. It is less than the minimum guideline figure. This value is based on the concentration which reduces tooth decay and is not mandatory.
Arsenic (total) - Concentrations are all less than 10 ug l^{-1}. There are no guideline or mandatory levels for total arsenic.
Arsenic (dissolved) - levels are generally close to 1 ug l^{-1}. This is significantly lower than the guideline and mandatory levels of 50 and 100 ug l^{-1} respectively.
Barium (total) - There is no relationship with flow. All values except one are well below the mandatory limit of 1000 ug l^{-1}. The mandatory level is for dissolved Ba, not total Ba. Dissolved Ba is likely to be very low when sulphate is present.
Boron (total) - boron is used in detergents and, as such would be expected to derive from point sources, generally sewage treatment works. The negative relationship between concentration and flow is consistent with this. All levels are below the dissolved boron guideline level of 1 mg l^{-1}. Although at low flows concentrations of total boron approach this, dissolved boron levels will be much lower. There are no mandatory levels but concentrations are below the prescribed level of 2 mg l^{-1}.
Cadmium (dissolved) - the majority of values are less than the limit of detection, which varied over the sampling period. All the limits of detection, and the few measured values are all considerably lower than the guideline value of 1 ug l^{-1}.
Chromium (total) - the majority of values lie around 1 ug l^{-1}. Two values are quite high but

none are greater than the mandatory level of 50 ug l^{-1}. There is no relationship with flow.
Chromium (dissolved) - levels are all lower than 5 ug l^{-1}. There are no mandatory levels for dissolved chromium.
Copper (total) - all values are about 10 ug l^{-1} except one which is still an order of magnitude less than the guideline level for dissolved copper (1000 ug l^{-1}). There are no mandatory levels for total copper.
Copper (dissolved) - all but three results are less than 10 ug l^{-1}. Even the highest levels are at least an order of magnitude less than the guideline level of 1000 ug l^{-1}.
Iron (total) - all values, except one are below 1 mg l^{-1}. There are no mandatory or guideline levels for total iron.
Iron (dissolved) - concentrations increase with increasing flow rate. At high flow rates levels approach but do not exceed the guideline level of 1 mg l^{-1}.
Lead (total) - concentrations are generally less than 10 ug l^{-1}. Only one concentration exceeds this level. There are no mandatory or guideline levels for total lead.
Lead (dissolved) - only a few data points are available. Most of these are less than values. All values are less than the mandatory level of 50 ug l^{-1}.
Manganese (total) - Data suggest an increase in concentration with flow. At high flows concentrations may approach the guideline level of 1 mg l^{-1} for dissolved manganese but all observed concentrations were below this levels. There are no guideline or mandatory levels for total manganese.
Mercury (dissolved) - only a few data were available, mostly below the limit of detection, which changed by and order of magnitude over the sampling period. All values are less than 0.1 ug l^{-1}, i.e. significantly lower than the guideline and mandatory levels of 5 and 1 ug l^{-1} respectively.
Nickel (total) - values show no relationship with flow. The majority of concentrations are less than 10 ug l^{-1}. There are no guideline or mandatory levels for total nickel.
Nickel (dissolved) - values show no relationship with flow. The majority of concentrations are less than 10 ug l^{-1}. There are no guideline or mandatory levels for dissolved nickel.
Zinc (total) - concentrations are typically between 10 and 100 ug l^{-1}. There is no relationship with flow. All values are significantly less than the guideline value of 1000 ug l^{-1} cited for dissolved zinc. There are no guideline or mandatory levels for total zinc.
Zinc (dissolved) - concentrations are typically between 10 and 100 ug l^{-1}. There is no relationship with flow. All values except one are significantly less than the guideline value of 1000 ug l^{-1}. Even the single rogue value is less than the guideline level.

Organics - detergents, solvents, PAH

Detergents (anionic) - There is some evidence for a decrease in concentration with increasing flow rate. Most values are below 0.1 mg l^{-1}. The three concentrations greater than this are all less than 1 mg l^{-1}. Anionic detergents are equivalent to "surfactants" named in the directive. The guideline level is defined relative to lauryl sulphate (M.Wt. = 288), whereas these data are defined relative to Monoxol OT (M.Wt.= 444). When defined relative to Monoxol OT the guideline becomes 0.77 mg l^{-1}. Although one concentration is close to this guideline, no concentrations exceed it.
Detergents (non-ionic) - only seven data are reported. All levels are less than 0.5 mg l^{-1}. There are no guideline or mandatory levels for non-ionic detergents.
Oil - only ten data points are available. They show no relationship with flow. All values are less than about 5 mg l^{-1}. This is the guideline level. All values are less than the mandatory

limit of 1 mg l^{-1}.
Total chloroform - data are scarce. Concentrations appear to be less than 0.5 ug l^{-1}. There are no guideline or mandatory levels for total chloroform.
Trichlorobenzene (total) - data are scarce. Concentrations appear to be less than 20 ng l^{-1}. There are no guideline or mandatory levels for total trichlorobenzene.
Halogenated solvents (total) - data are scarce. All samples were collected at a similar flow rate. Concentrations range from about 5 down to less than 0.1 ug l^{-1}. There are no guideline or mandatory levels for total halogenated solvents.
PAH total (measured) - this refers to a bulk measurement of PAH. Values range between about 8 to 500 ng l^{-1} with no obvious relationship with flow. All values are significantly less than the mandatory level of 1000 ng l^{-1}.
PAH total -refers to a calculated sum of individual PAHs: Fluoranthene, Benzo (B) Fluoranthene, Benzo (K) Fluoranthene, Benzo (A) Pyrene, Indeno (123CD) Pyrene, and Benzo (GHI) Perylene. This sum represents a maximum since in the calculation it was assumed that values below detection limit were equal to the detection limit. Concentrations are higher than the total PAH measurement ranging from 10 to about 800 ng l^{-1}. They are below the mandatory level of 1000 ng l^{-1}. Total PAH concentrations also were measured directly (see Fig. "Total PAH (measured)")

Pesticides

HCH gamma (Lindane) - data show no relationship with flow. Concentrations are generally below 20 ng l^{-1}. All values are well below the mandatory level of 100 ng l^{-1}.
HCH (total) - data show no relationship with flow. Concentrations are generally below 50 ng l^{-1}. All these values for total HCH are well below the mandatory levels for individual compounds of 100 ng l^{-1}.
Drins (total) - (=Dieldrin + Aldrin) data show no relationship with flow. Concentrations are generally below 10 ng_l^{-1}. This summation is significantly below the mandatory levels for individual compounds of 100 ng l^{-1}.
Organo-Chlorine pesticides - (summation of dieldrin, aldrin, DDT, DDE, TDE, Lindane, alpha HCH.) Very few points. This summation is significantly below the mandatory levels for individual compounds of 100 ng l^{-1}.
DDT (total) - total of 14 data point. No relationship with flow. All values a bout 10 ng l^{-1}. Considerably lower than the mandatory limit of 100 ng l^{-1}.
Atrazine - Concentrations of atrazine at high flows are scarce. At low flows half the data points exceed the mandatory level of 100 ng l^{-1}. On occasions concentrations approach 1000 ng l^{-1}.
Simazine - Concentrations of simazine at high flows are scarce but there is a suggestion that concentrations reduce significantly at high flows. At low flows a significant proportion of the data exceed the mandatory level of 100 ng l^{-1}. On occasions concentrations approach 1000 ng l^{-1}.
Triazine - the sum of atrazine and simazine. Almost all concentrations exceed 100 ng l^{-1}, with occasional values exceeding 1000 ng l^{-1}. There are no longer any guideline levels for total pesticide type.
PCB (total) - there are few data points. Data show no relationship with flow. Values are typically just above 10 ng l^{-1}. There is one outlier which is greater than 100 ng l^{-1}. There are no guideline or mandatory levels for total PCBs.

Other determinands

Those other determinands with too few measurements to graph are summarised in the Table 1. In cases where only one measured value was available, this is stated. In all other cases 5 or more (usually around 12-15) measurements were available, but most values were below the limit of detection (< LoD). In many cases all but one of the measurements was < LoD: this is stated in the notes. Otherwise a large majority were < LoD. Where possible, the maximum measured value is given. For these determinands, guideline (g) and mandatory (m) values are given for phenols (g= 10 ug l^{-1}; m= 100 ug l^{-1}); and cyanide (m= 50 ug l^{-1}). In all cases concentrations do not exceed these limits. Similarly no individual pesticide exceeds the mandatory limit of 100 ng l^{-1}.

CONCLUSIONS

Note: the data analysed are from a site down stream of a sewage discharge. The abstraction point is upstream of this site and concentrations of all pollutants will be lower at the abstraction site.

1. Sodium, magnesium, hardness chloride, alkalinity, nitrate, total phosphate, ortho-phosphate, boron, and anionic detergents all showed an increase in concentration to lower flows.

2. Colour, dissolved iron and total manganese showed an increase in concentration with higher flows.

3. All measured determinands had no concentrations above either guideline or mandatory levels except colour, pH, COD, Kjeldahl nitrogen, nitrate, ortho-phosphate, atrazine, simazine and triazine.

4. A significant proportion of samples had colour levels exceeding the guidelines, occasional levels exceeded mandatory levels, approximately 3%, all at high flows.

5. One pH result out of 19 exceeded the guideline levels. There are no mandatory levels.

6. 6 out of 16 COD measurements exceeded the guideline level. There are no mandatory levels.

7. 3 out of 13 Kjeldahl nitrogen levels exceeded guideline levels but there are no mandatory levels. All concentrations exceeded the prescribed level but concentrations will reduce significantly during water treatment.

8. 2 out of 91 nitrate concentrations exceeded the mandatory levels. These levels are obviously anomalous and may be transcription errors in the original data.

9. All ortho-phosphate levels exceeded the guideline levels. If water is not to be stored in a reservoir prior to treatment it will not be a problem. However it also exceeds the prescribed level for drinking water.

10. At high flows dissolved iron approaches guideline levels but no data exceed it.

11. At high flows (>10 cumec) alkalinity is below the prescribed minimum of 49 mg l^{-1} $CaCO_3$.

12. The majority of atrazine, simazine and triazine concentrations exceed the mandatory level.

RECOMMENDATIONS

1. The only determinand at Hartlake which shows high concentrations at low flows and exceeds its guideline and mandatory levels is phosphate. Since these levels are exceeded at all flows the contractor sees no grounds for the NRA's statement concerning quality at low flows. It is recommended that S.E. Water ask the NRA to be more specific about their comments.

2. Consideration should be given to the inclusion on the works of plant capable of dealing with colour levels above mandatory levels at high flows. Alternatively a policy of limiting abstraction at flows greater than 10 cumec could be instigated.

3. pH should not be a problem.

4. Since COD and Kjeldahl nitrogen have no mandatory value, concentrations exceeding the guideline should not pose a problem.

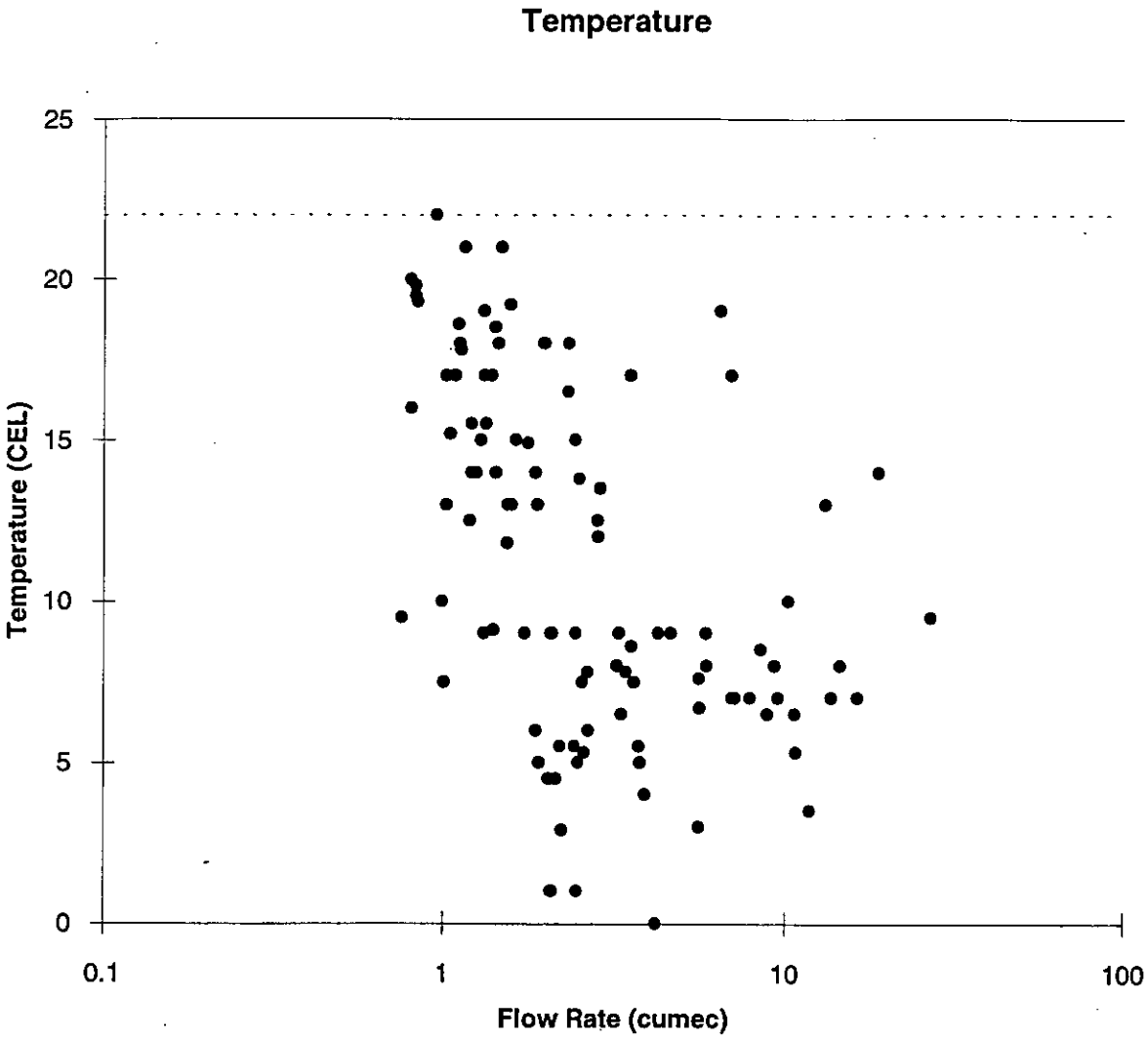
5. Ortho-phosphate levels exceed prescribed levels at all flow rates. Consideration should be given to the requirement for treatment plant to reduce these levels before being put into supply.

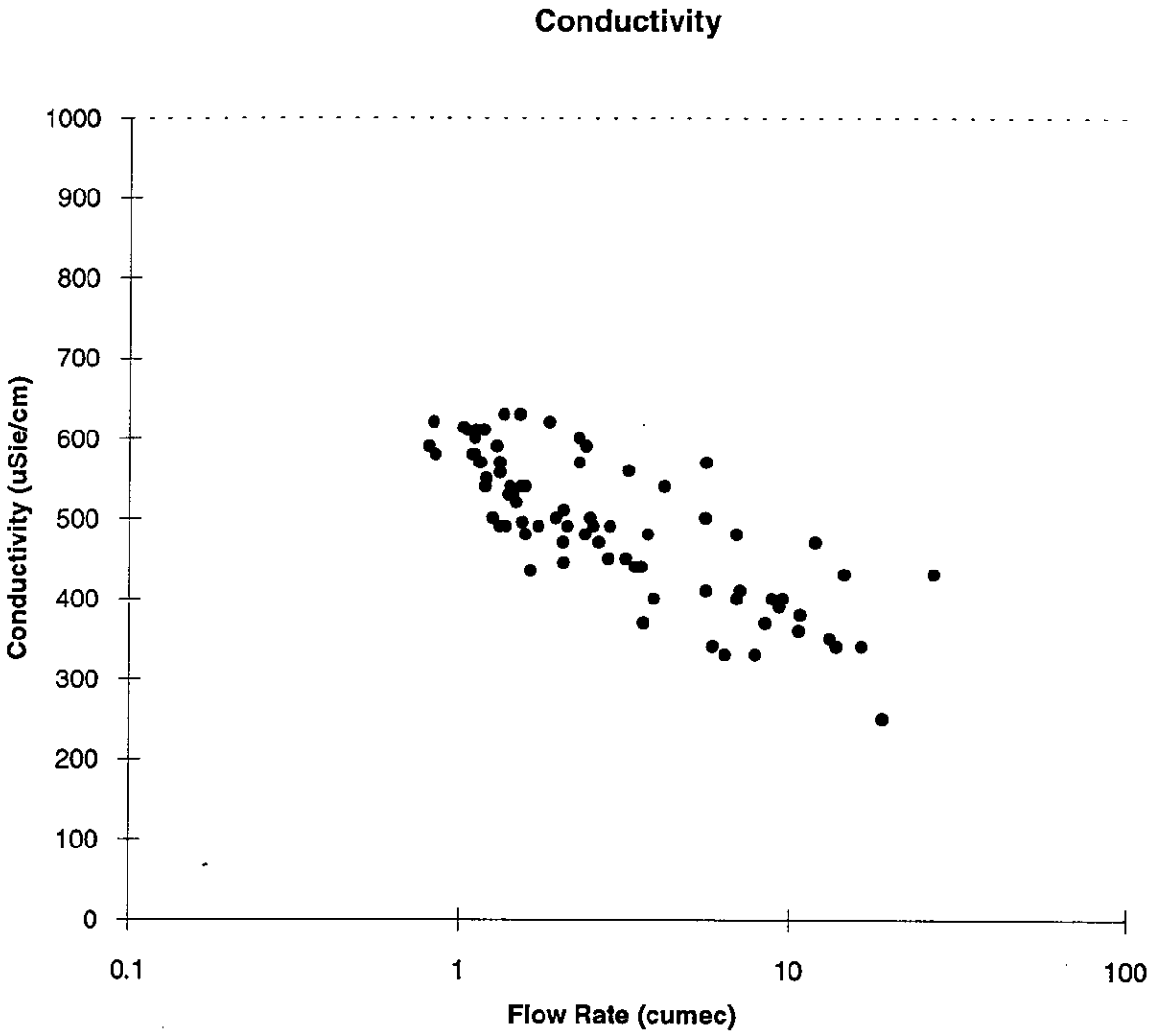
6. Atrazine and simazine frequently exceed mandatory levels. Consideration should be given to the inclusion in the plant of activated charcoal or some other means of reducing these compounds to acceptable levels.

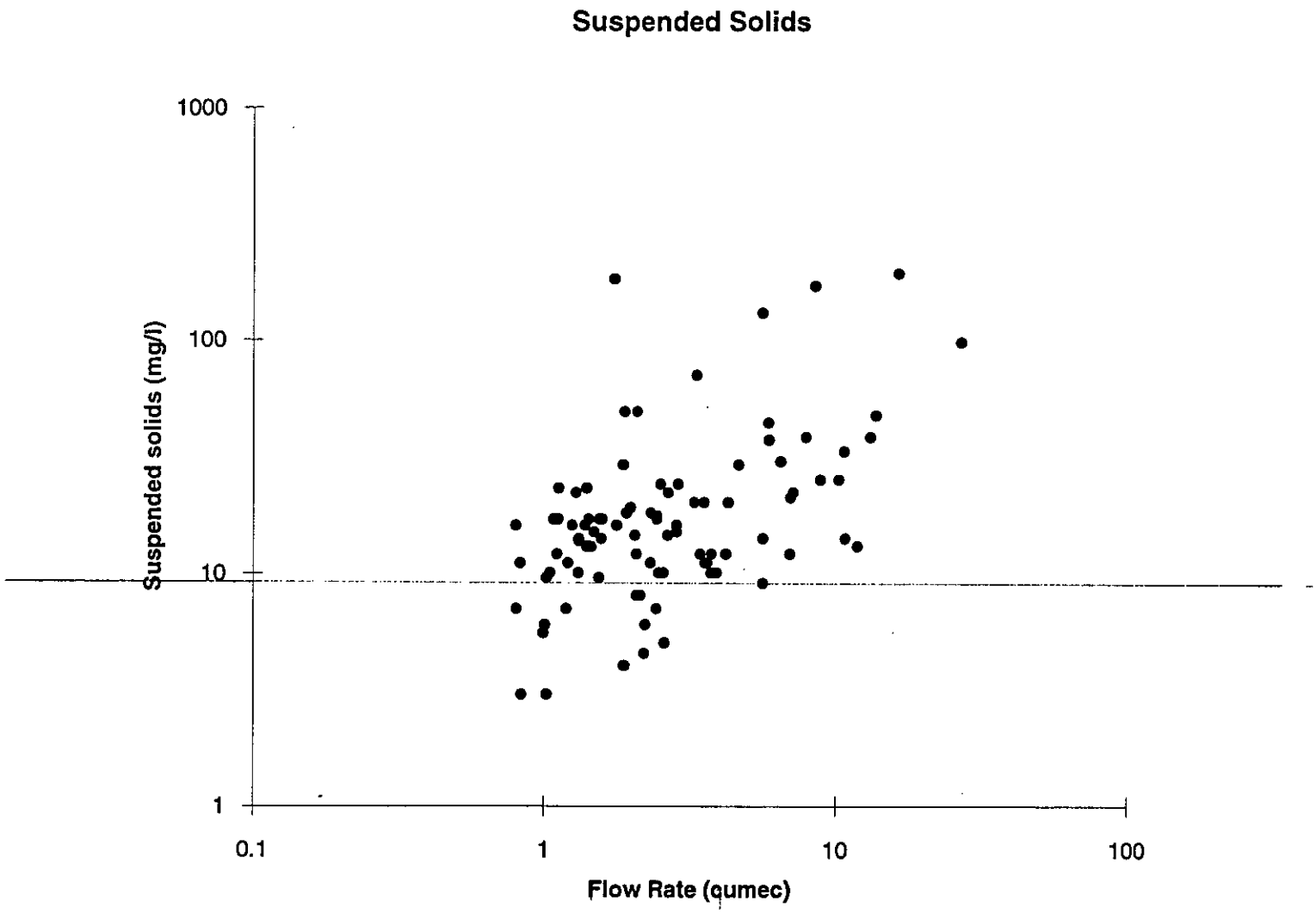
Appendix 1. Plots of concentration v flow for a number of determinands measured on samples from Hartlake on the river Medway at Tonbridge.

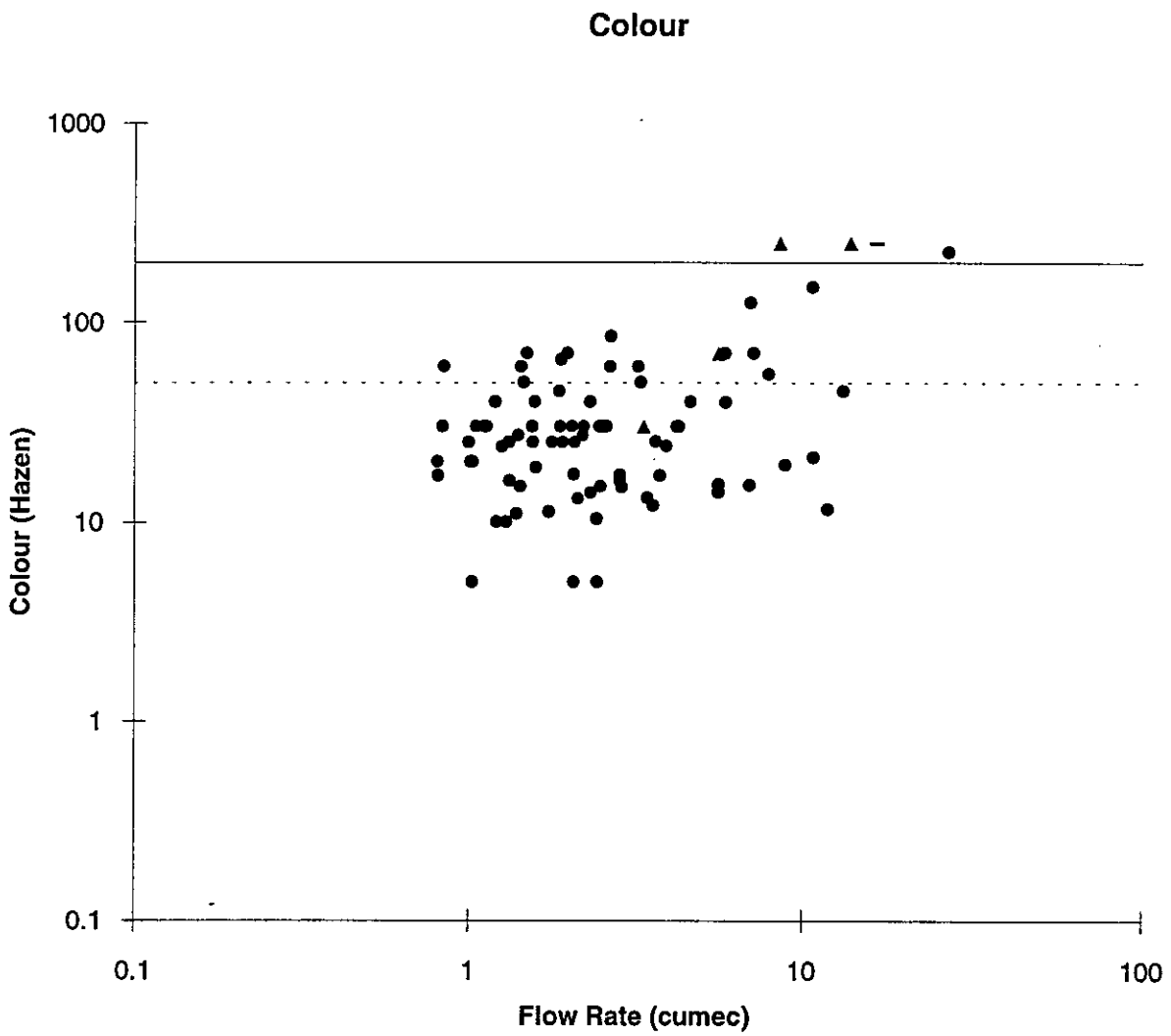
Key

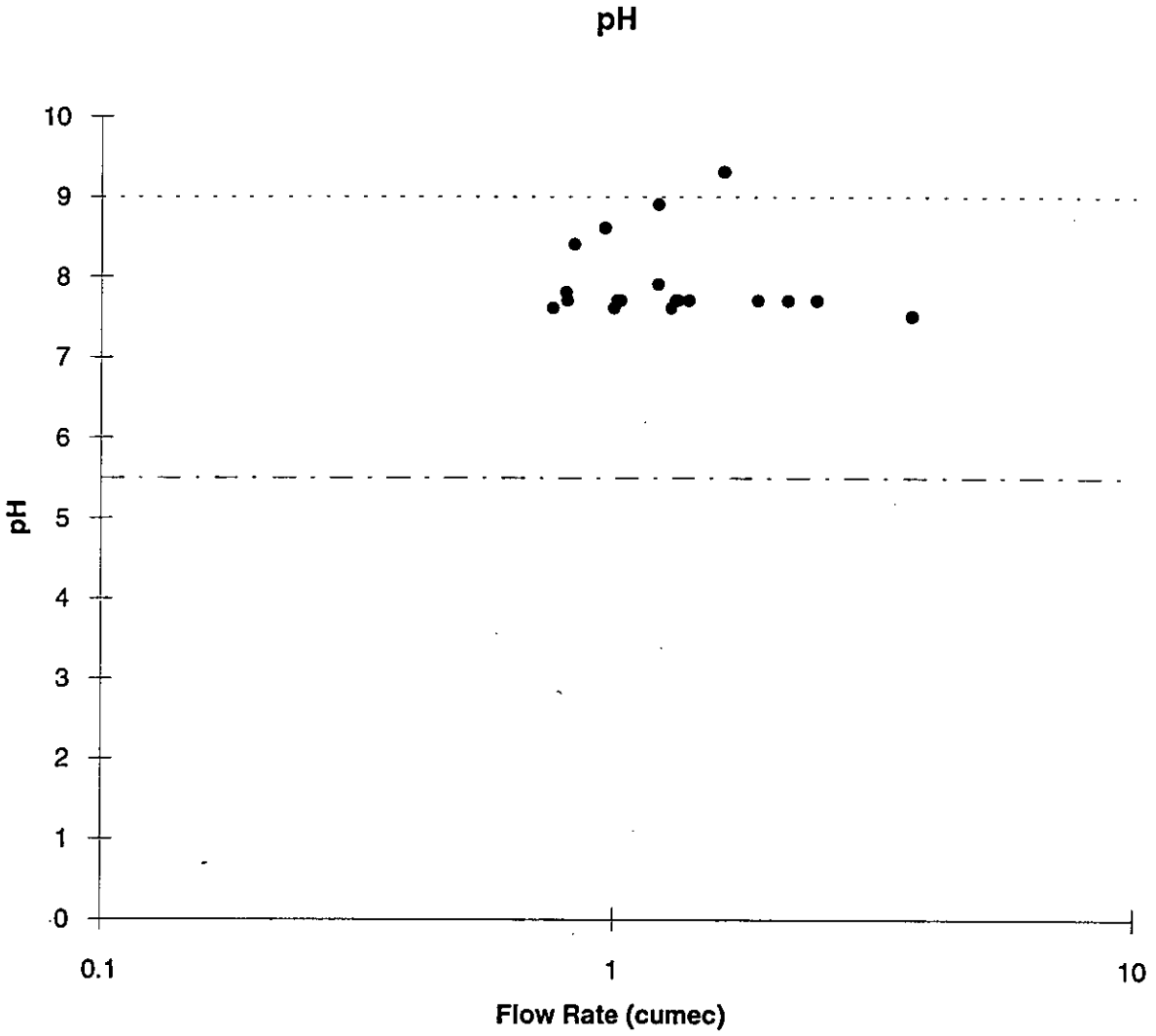
	Measured value
–	"Less than" value
▲	"Greater than" value
——	Mandatory upper limit
----	Guideline upper limit
— - —	Guideline lower limit

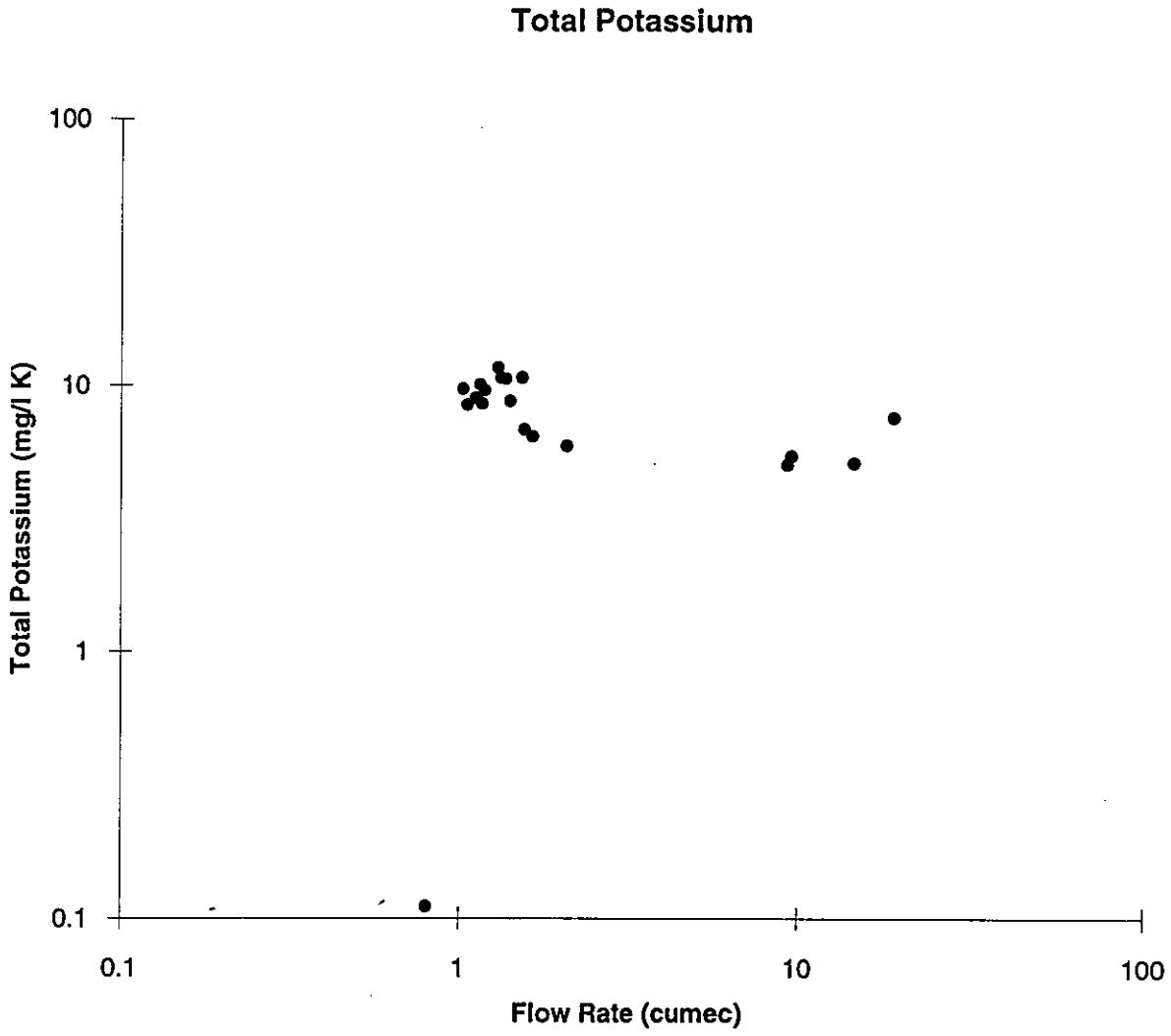

Temperature
25
20
15
10
5
0
Temperature (CEL)
0.1
1
10
100
Flow Rate (cumec)

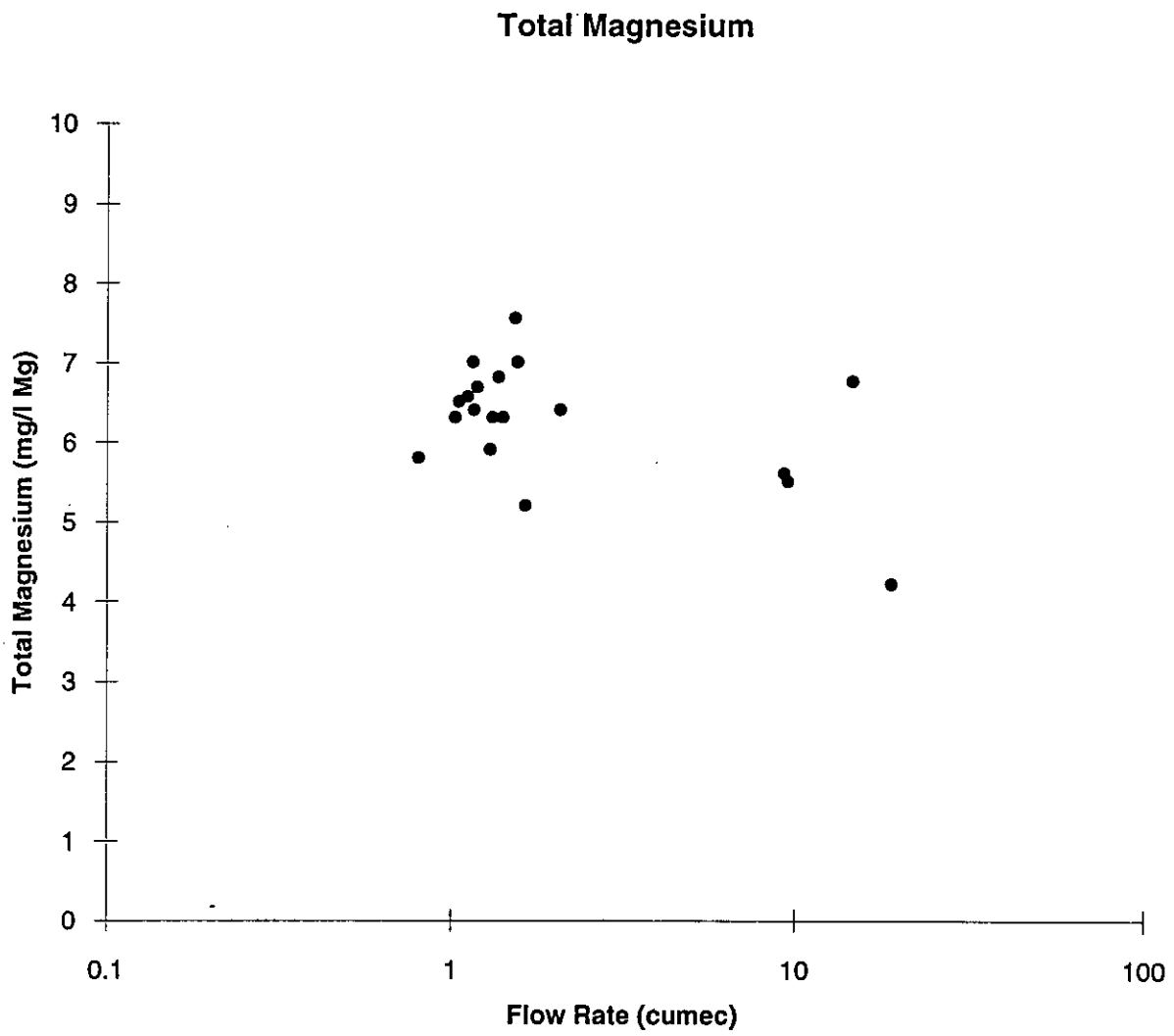

Conductivity
1000
900
800
700
600
500
400
300
200
100
0
Conductivity (uSie/cm)
0.1
1
10
100
Flow Rate (cumec)

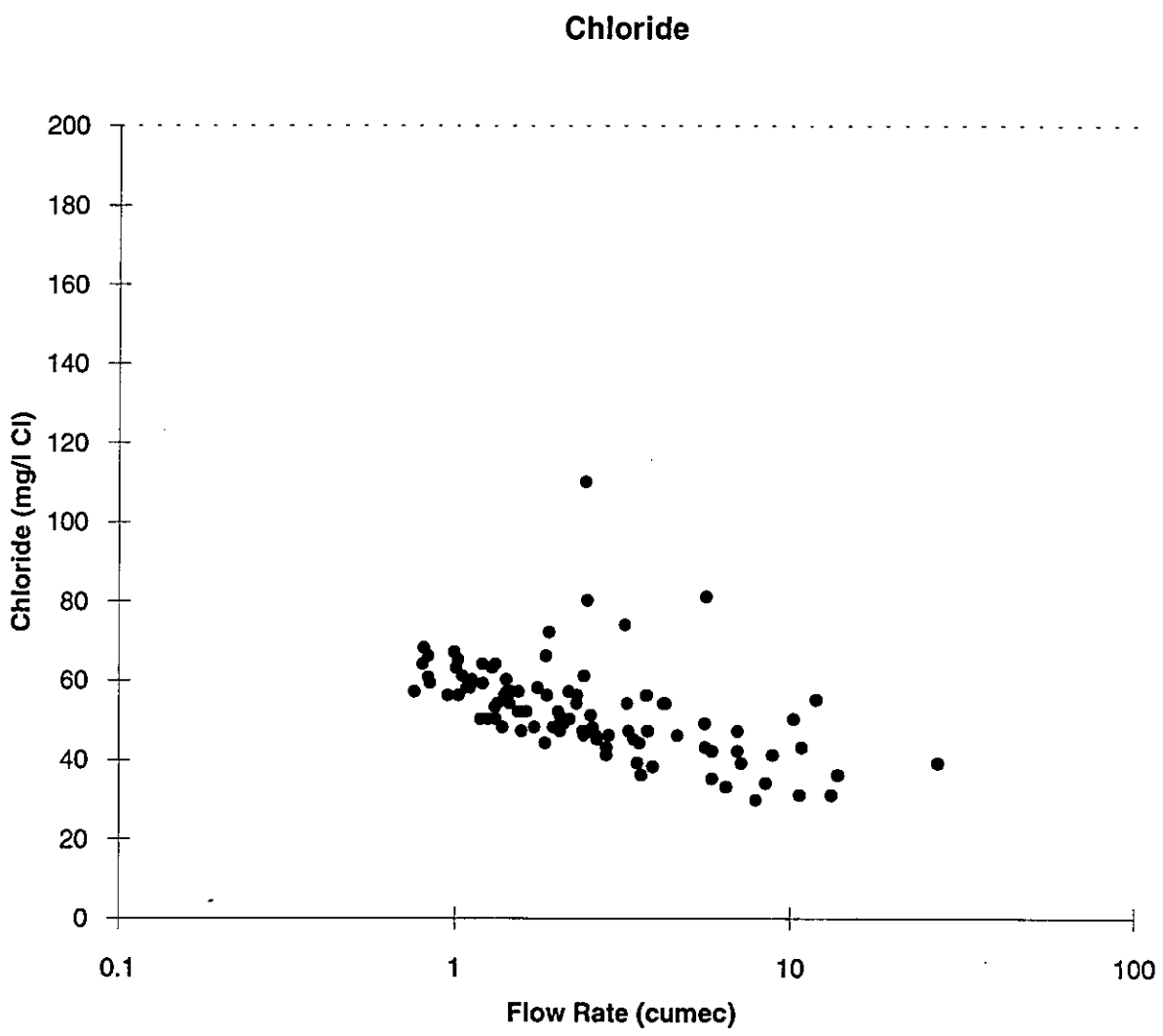

Suspended Solids
1000
100
10
1
Suspended solids (mg/l)
0.1
1
10
100
Flow Rate (qumec)

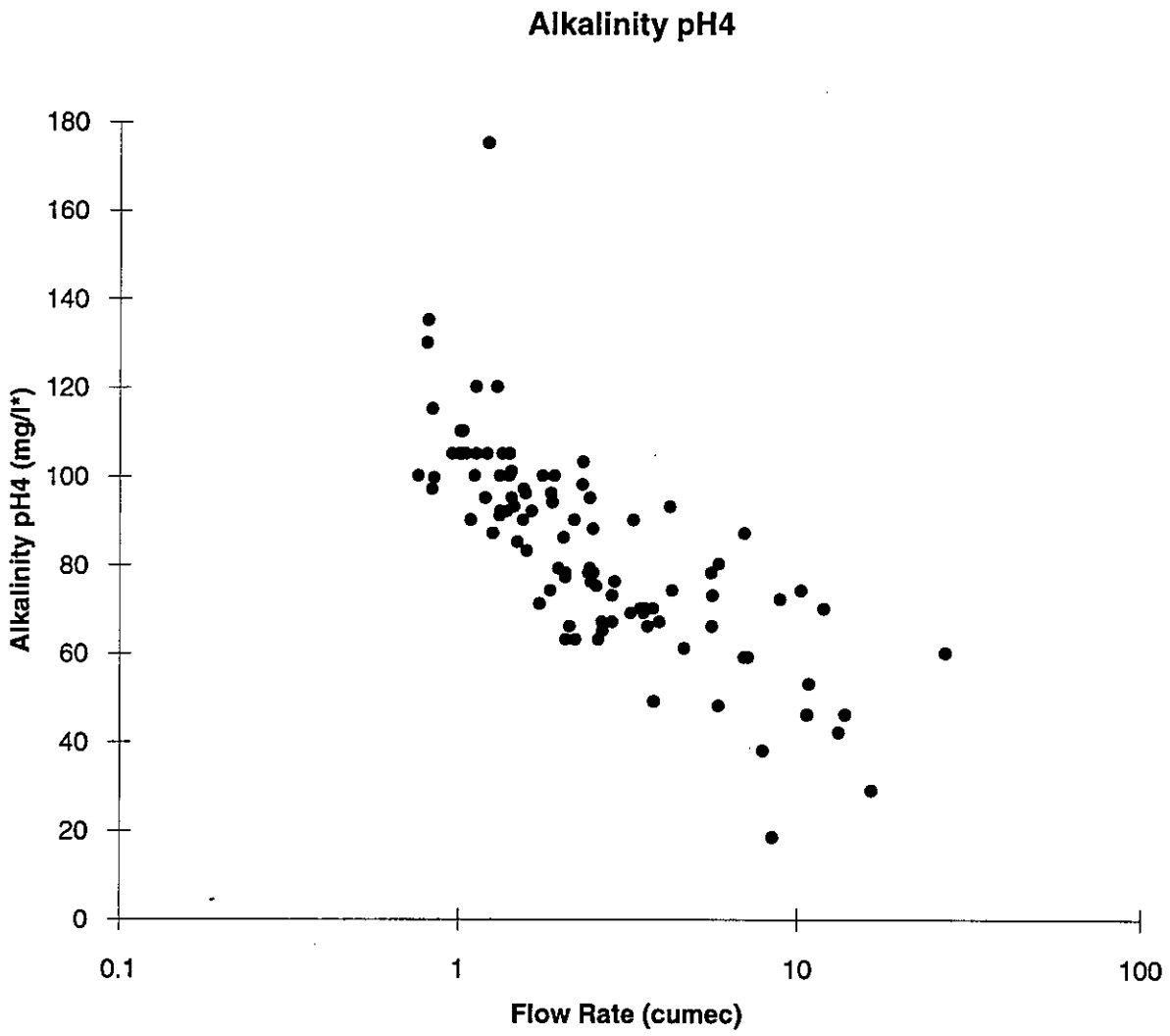

Colour
1000
100
10
1
0.1
Colour (Hazen)
0.1
1
10
100
Flow Rate (cumec)

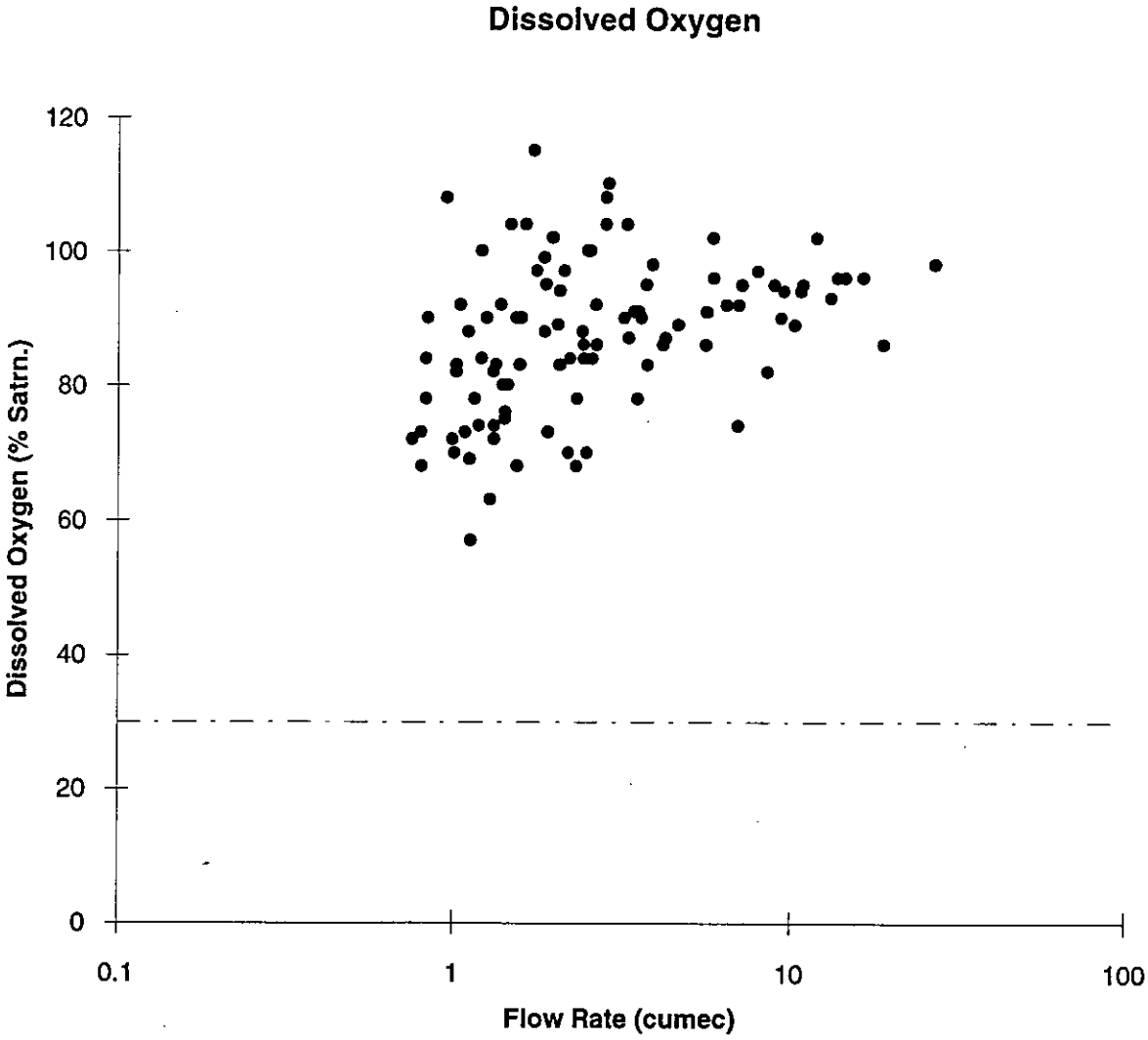

pH
10
9
8
7
6
5
4
3
2
1
0
pH
0.1
1
10
Flow Rate (cumec)

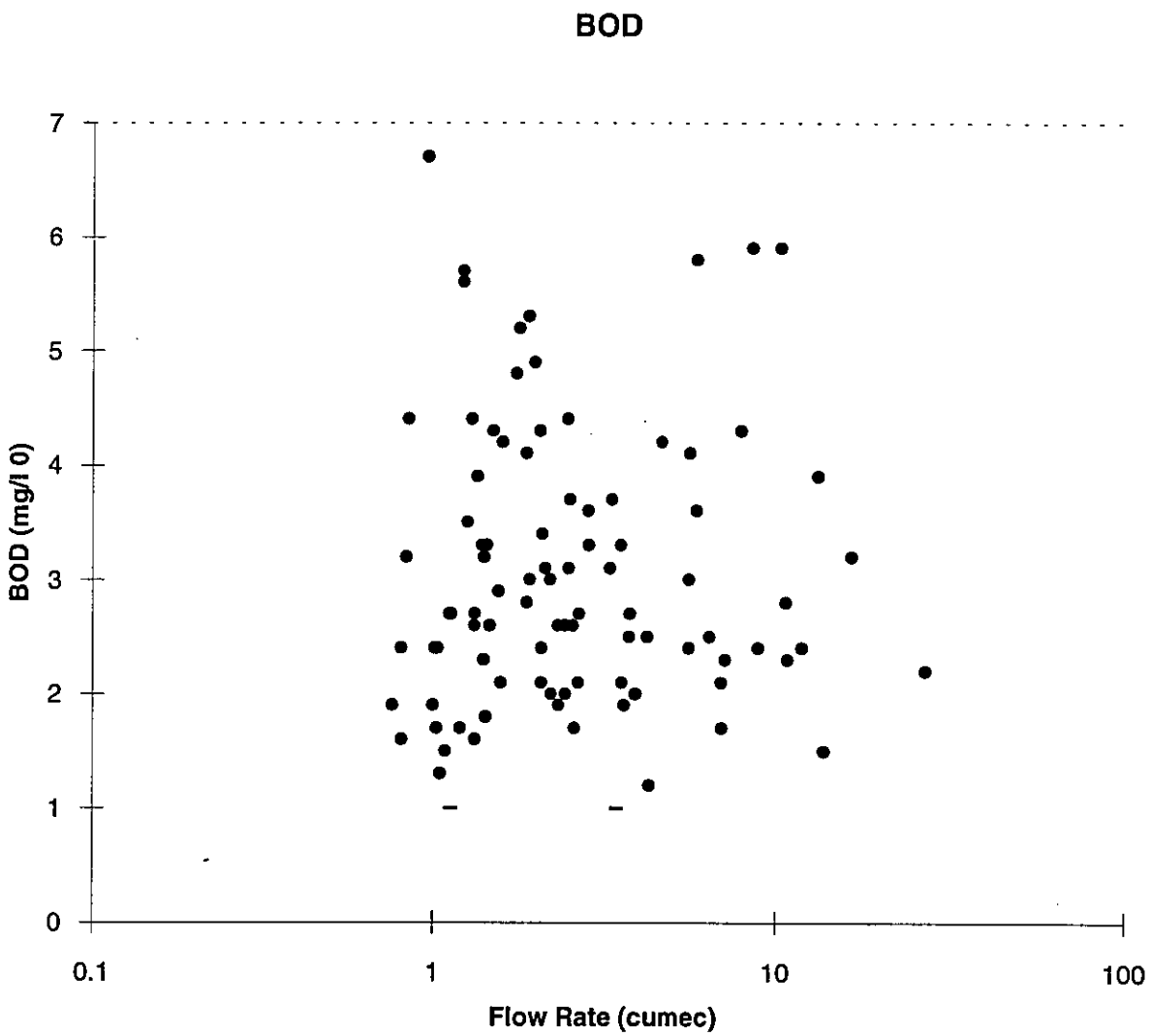

Total Potassium
100
10
1
0.1
Total Potassium (mg/l K)
0.1
1
10
100
Flow Rate (cumec)

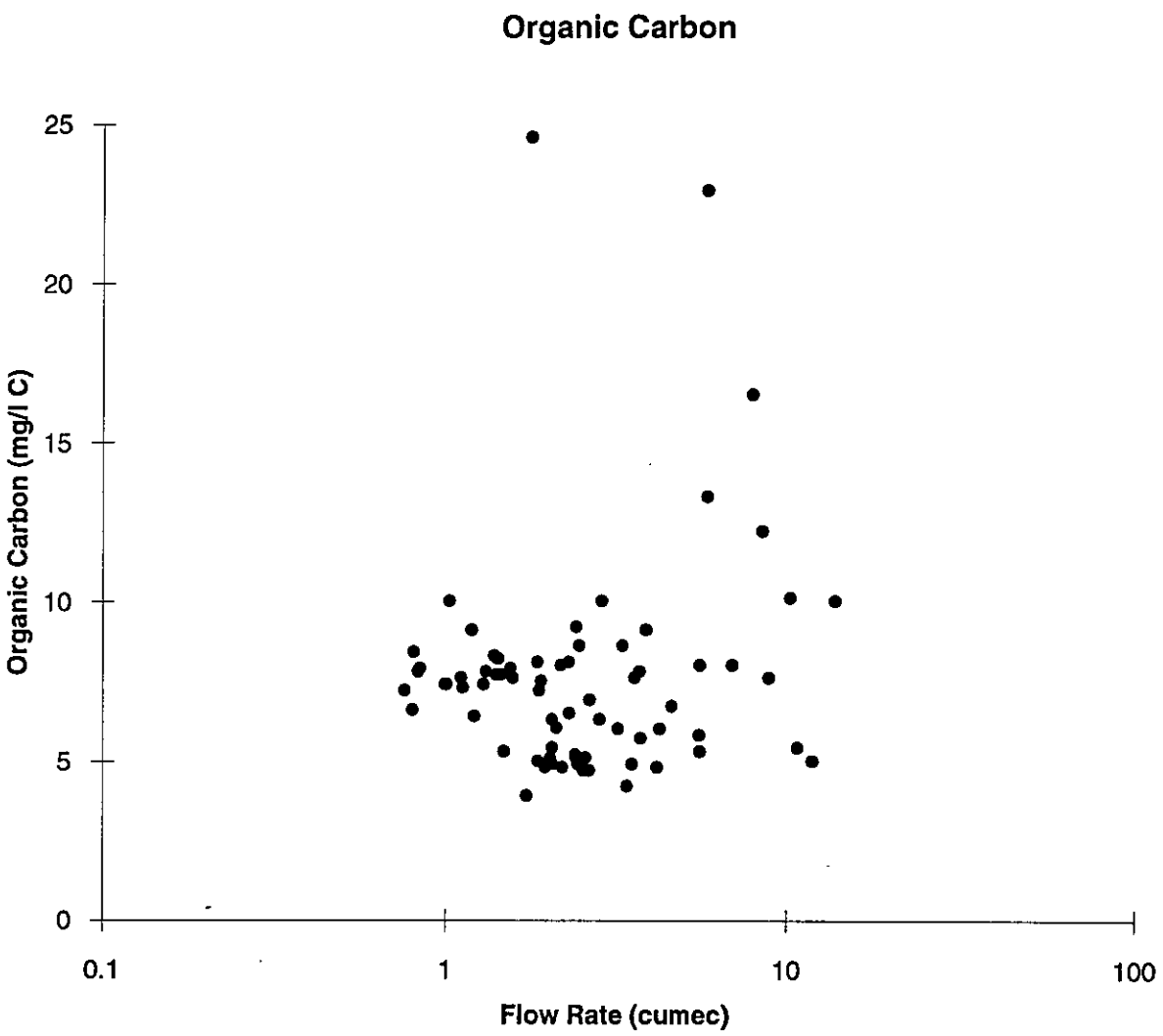

Total Magnesium
Total Magnesium (mg/l Mg)
10
9
8
7
6
5
4
3
2
1
0
0.1
1
10
100
Flow Rate (cumec)


Chloride
200
180
160
140
120
100
80
60
40
20
0
Chloride (mg/l Cl)
0.1
1
10
100
Flow Rate (cumec)

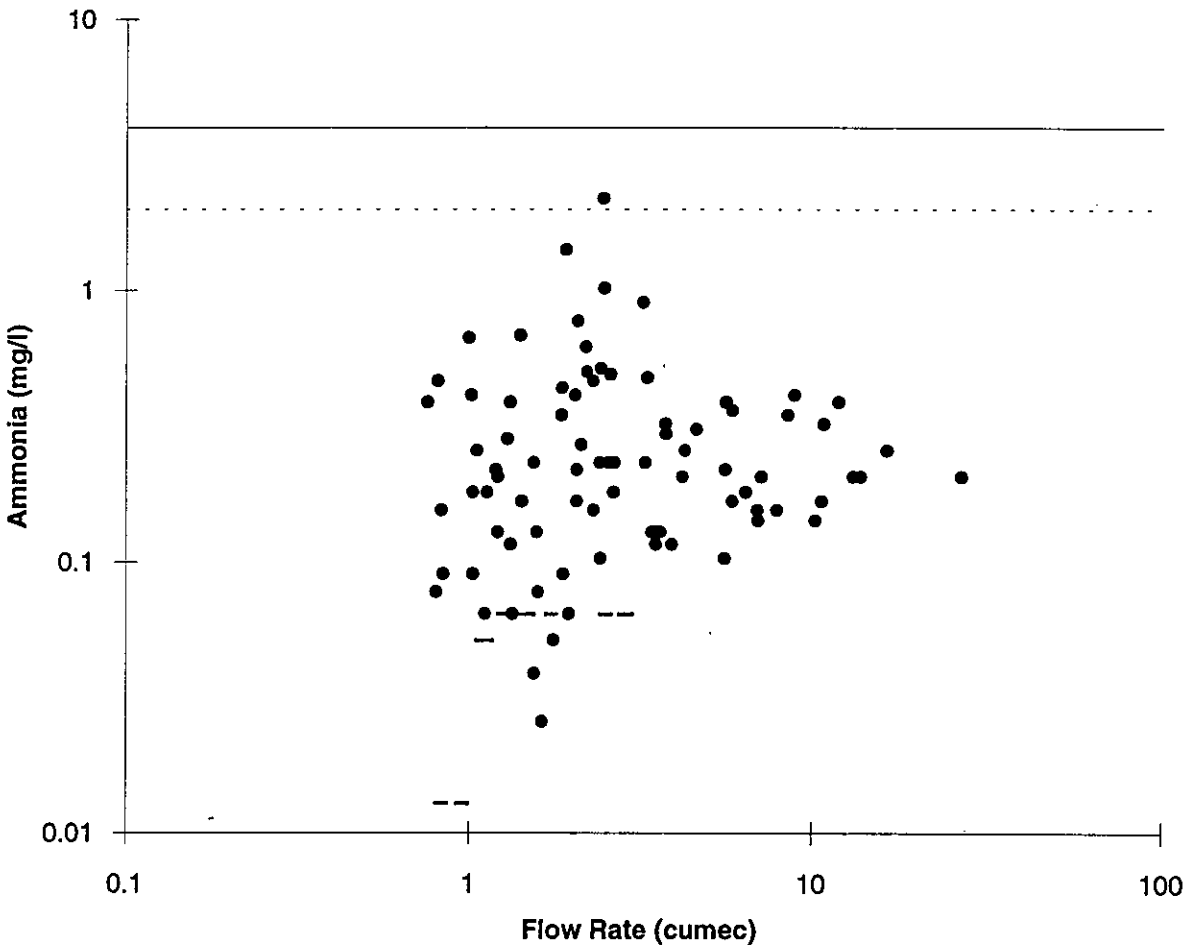

Alkalinity pH4
Alkalinity pH4 (mg/l*)
180
160
140
120
100
80
60
40
20
0
0.1
1
10
100
Flow Rate (cumec)

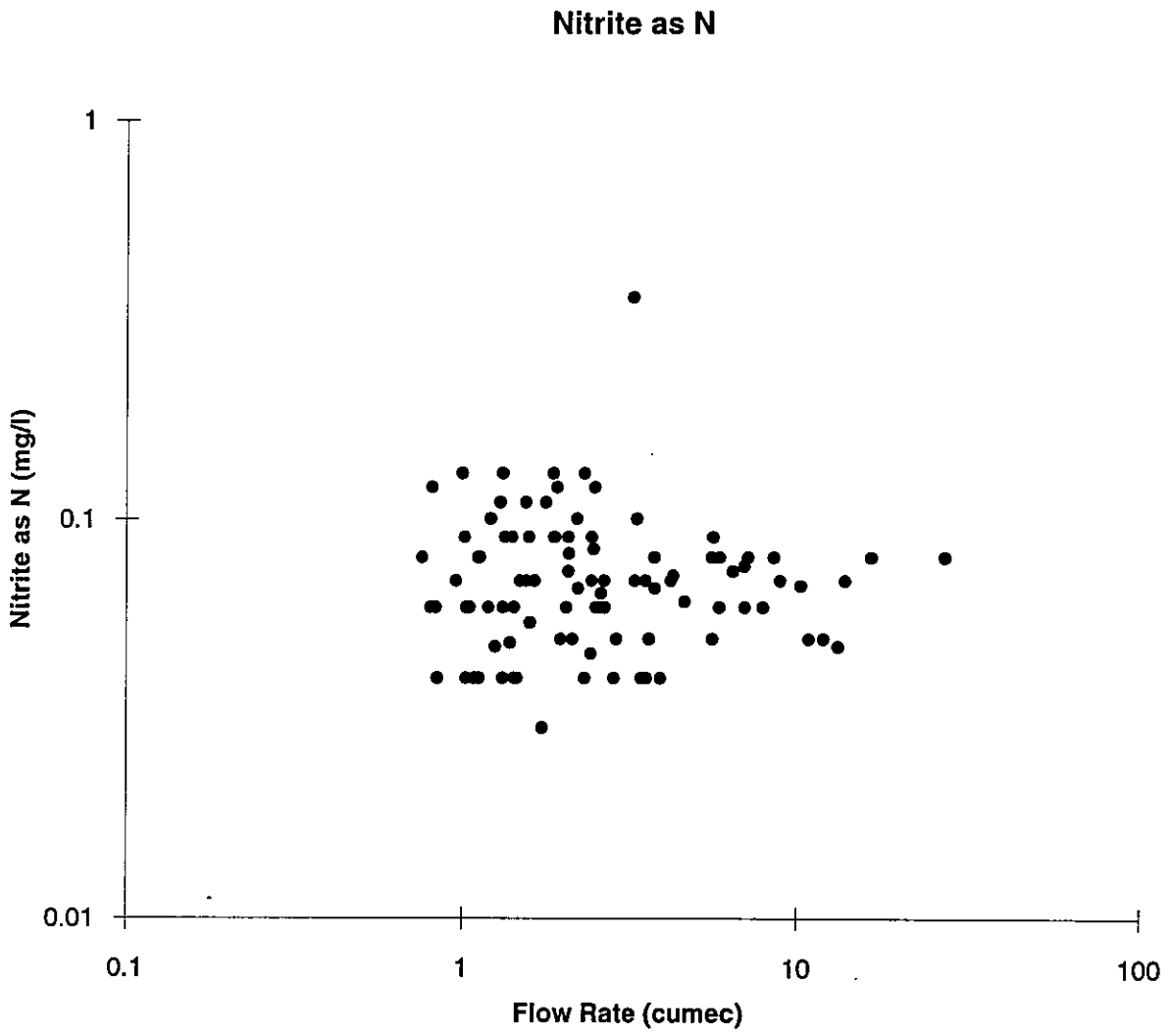

Dissolved Oxygen
120
100
80
60
40
20
0
Dissolved Oxygen (% Satrn.)
0.1
1
10
100
Flow Rate (cumec)

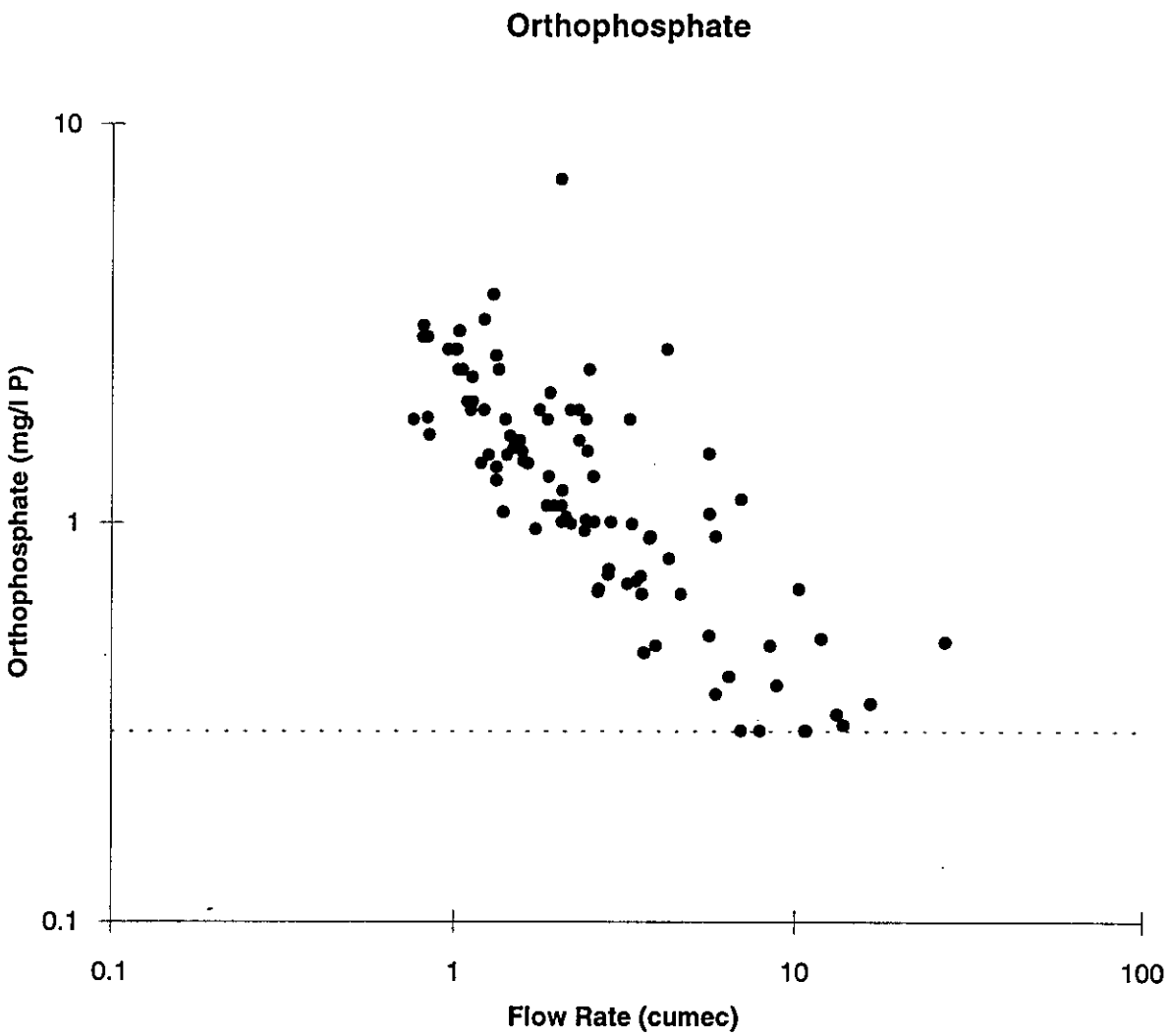

BOD
7
6
5
4
3
2
1
0
BOD (mg/l 0)
0.1
1
10
100
Flow Rate (cumec)

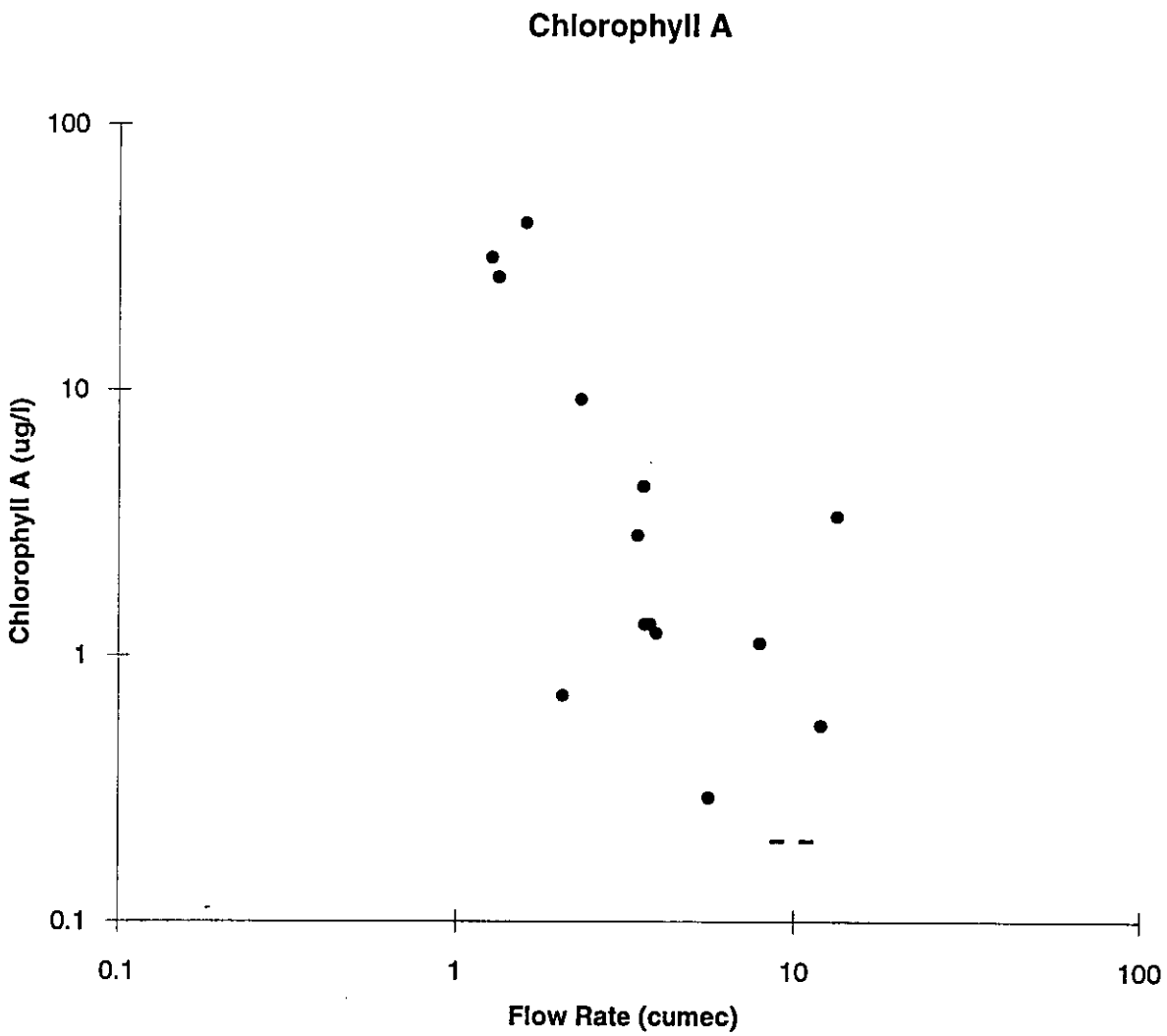

Organic Carbon
Organic Carbon (mg/l C)
25
20
15
10
5
0
0.1
1
10
100
Flow Rate (cumec)

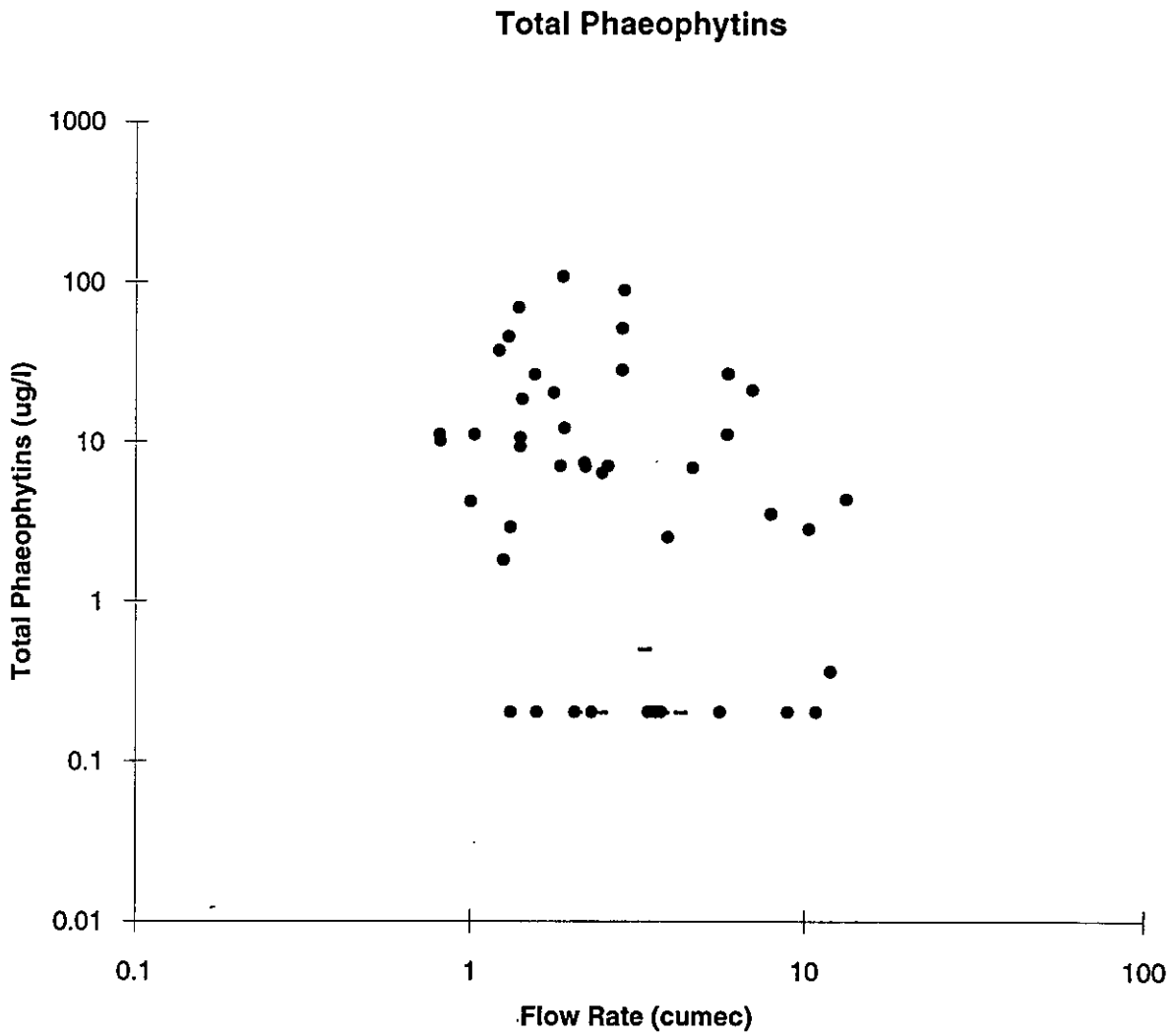
Ammonia

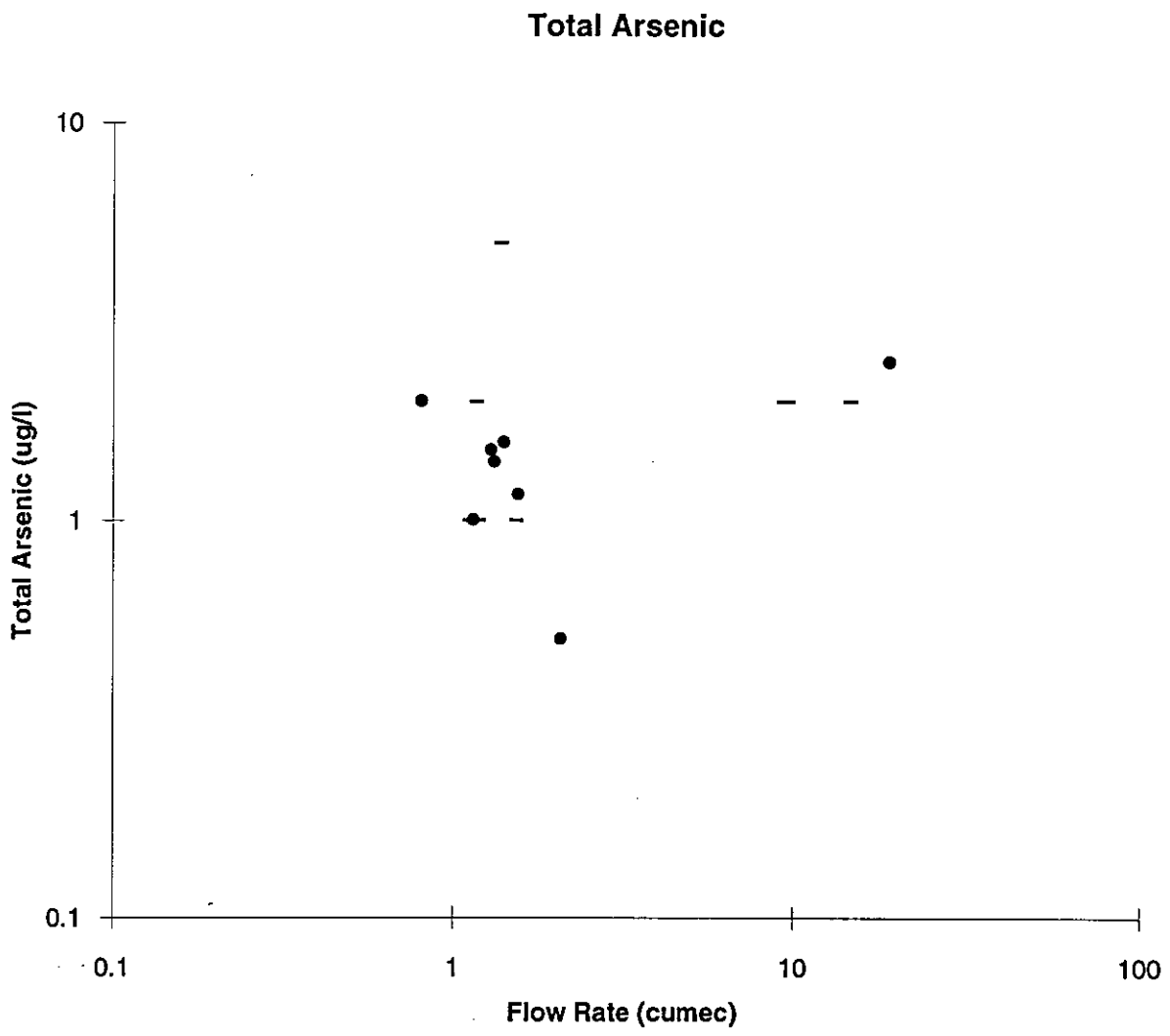


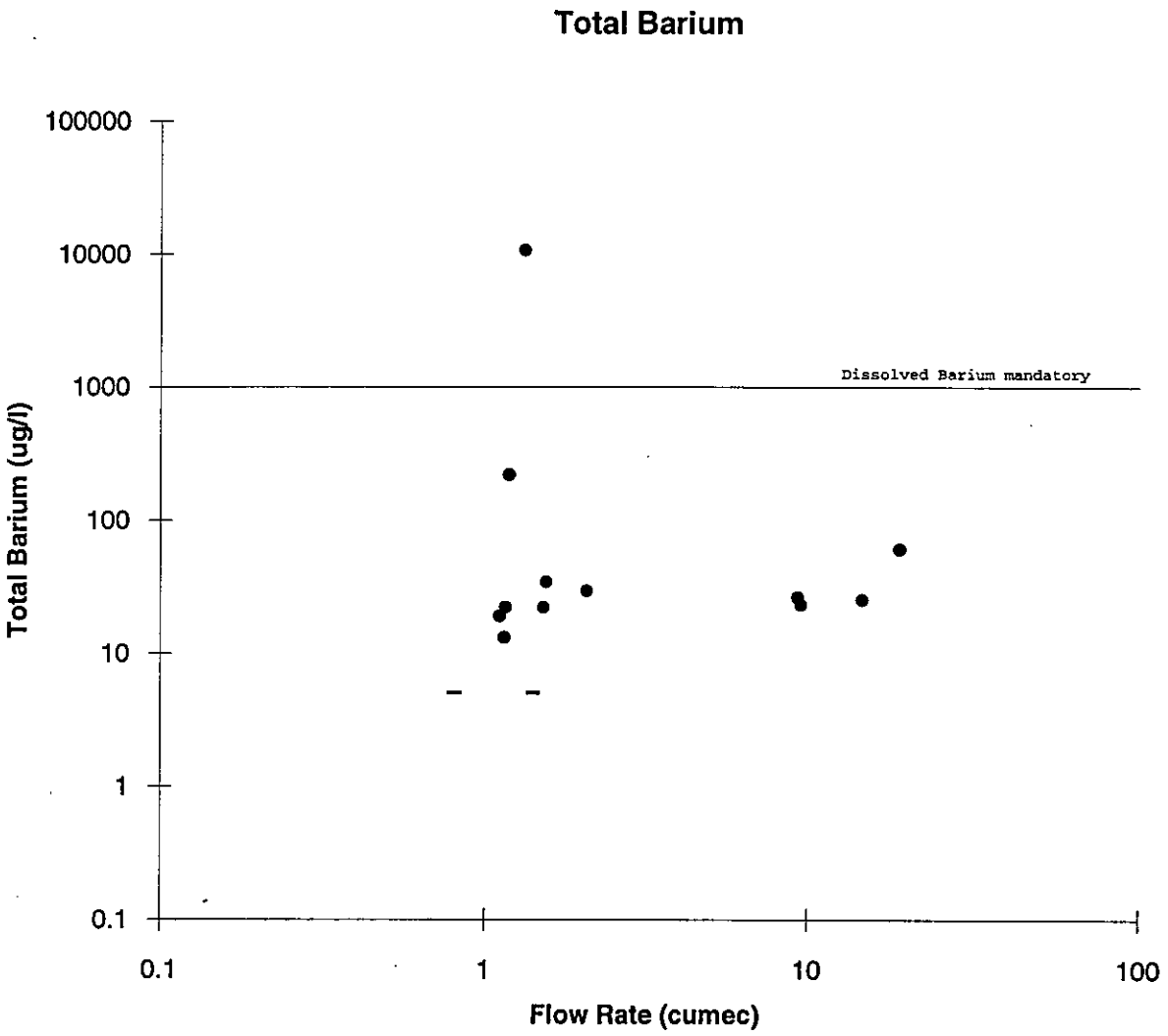

Nitrite as N
1
0.1
0.01
Nitrite as N (mg/l)
0.1
1
10
100
Flow Rate (cumec)


Orthophosphate
10
1
0.1
Orthophosphate (mg/l P)
0.1
1
10
100
Flow Rate (cumec)

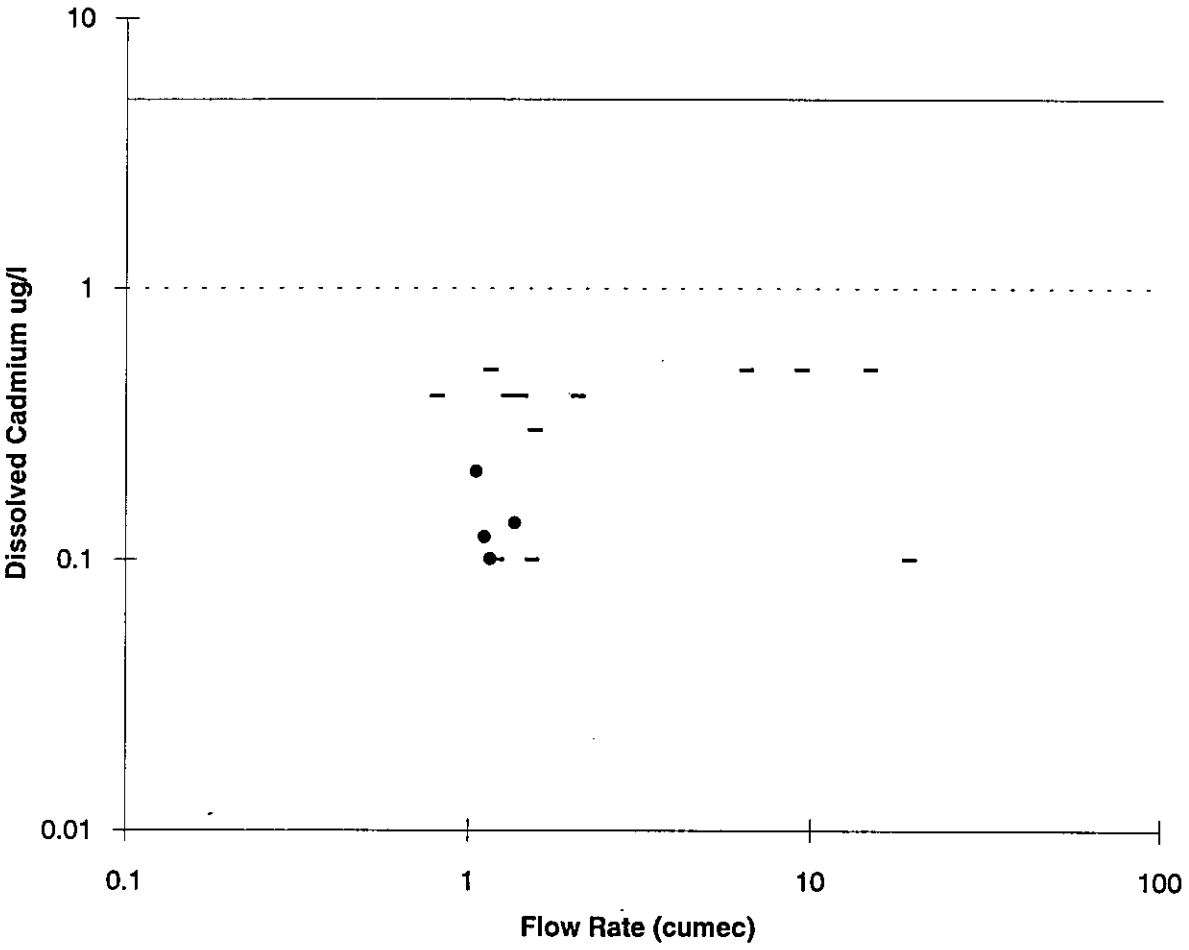

Chlorophyll A
100
10
1
0.1
Chlorophyll A (ug/l)
0.1
1
10
100
Flow Rate (cumec)

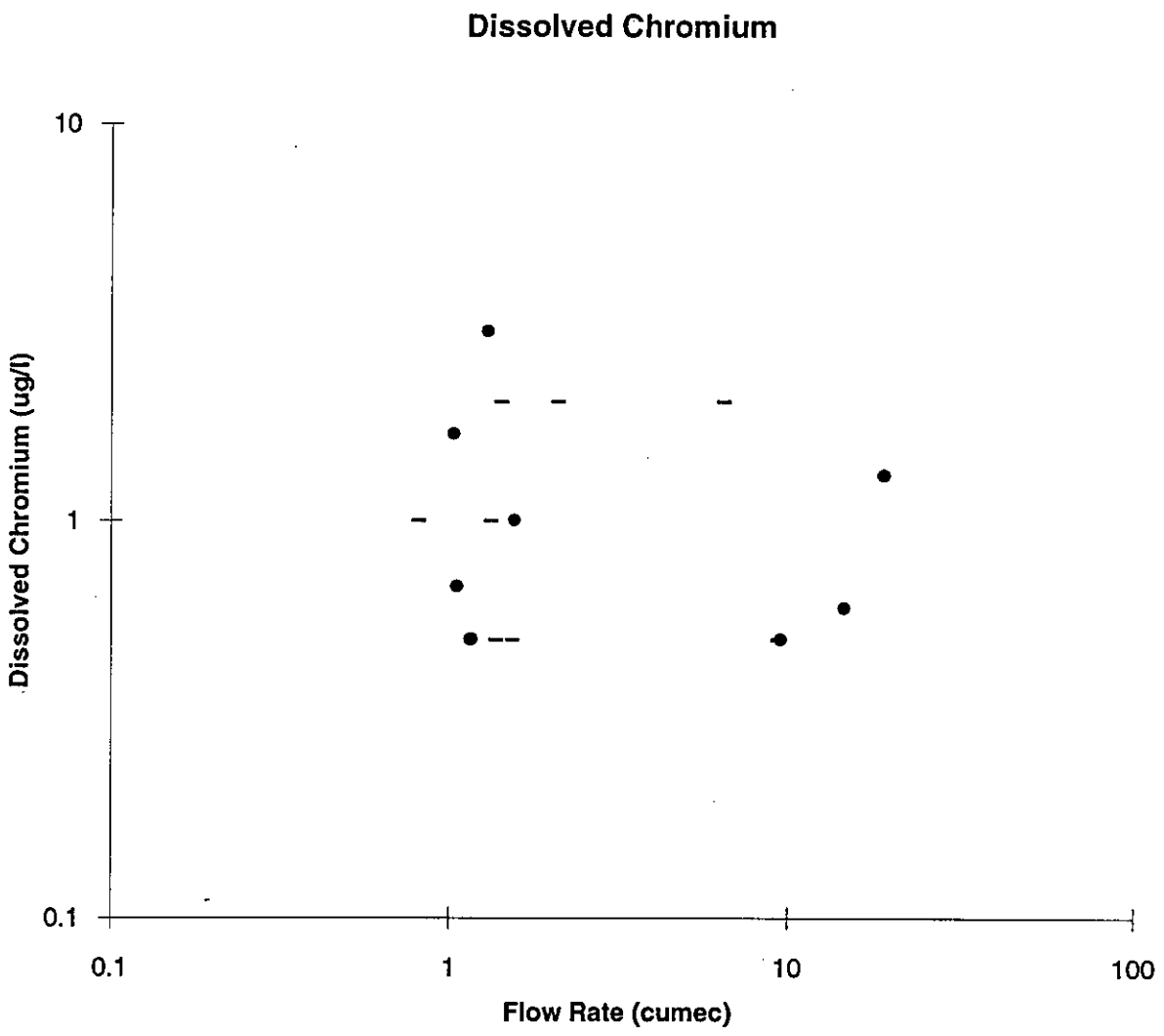

Total Phaeophytins
1000
100
10
1
0.1
0.01
Total Phaeophytins (ug/l)
0.1
1
10
100
Flow Rate (cumec)

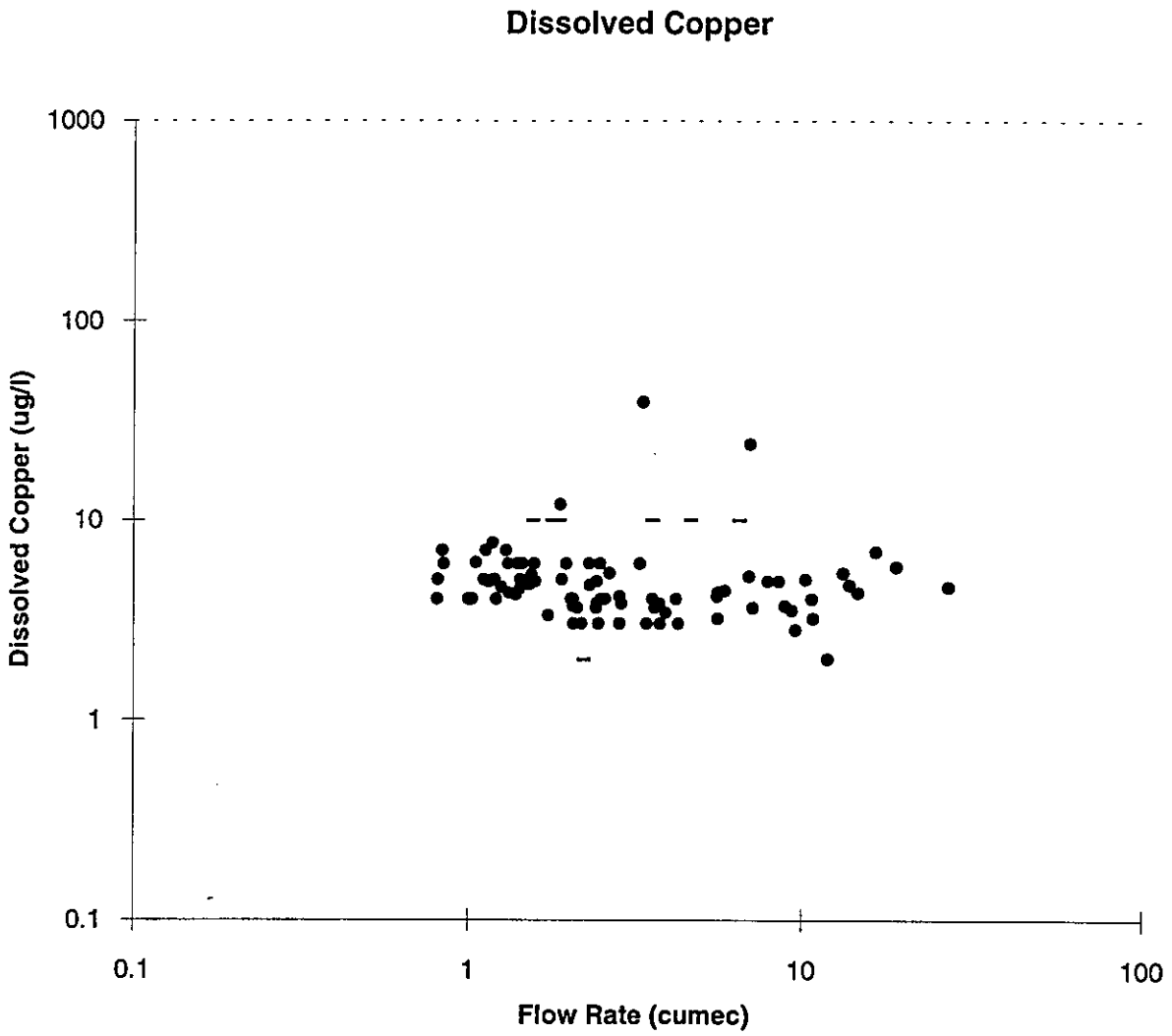

Total Arsenic
10
1
0.1
Total Arsenic (ug/l)
0.1
1
10
100
Flow Rate (cumec)

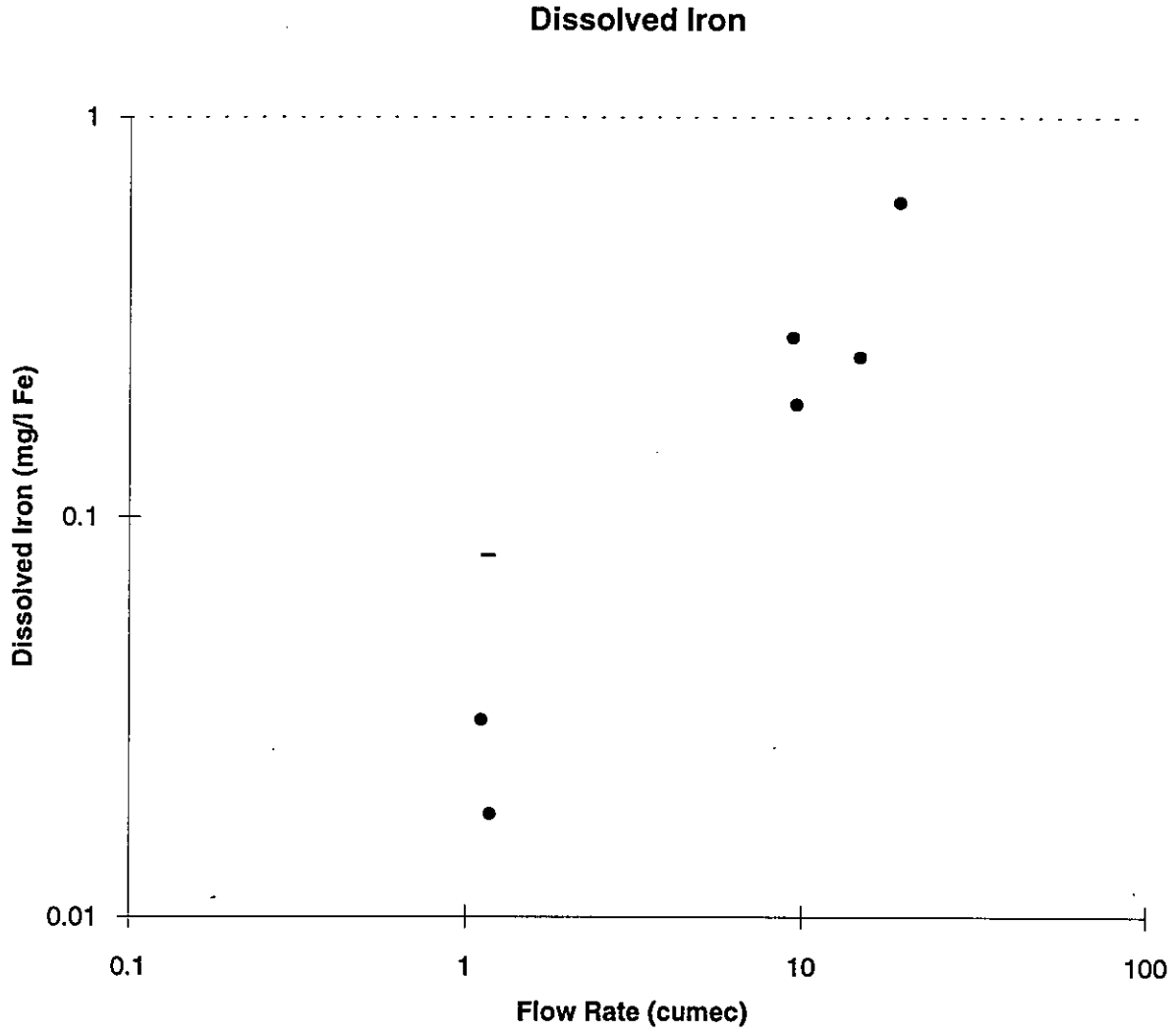

Total Barium
100000
10000
1000
100
10
1
0.1
Total Barium (ug/l)
Dissolved Barium mandatory
0.1
1
10
100
Flow Rate (cumec)

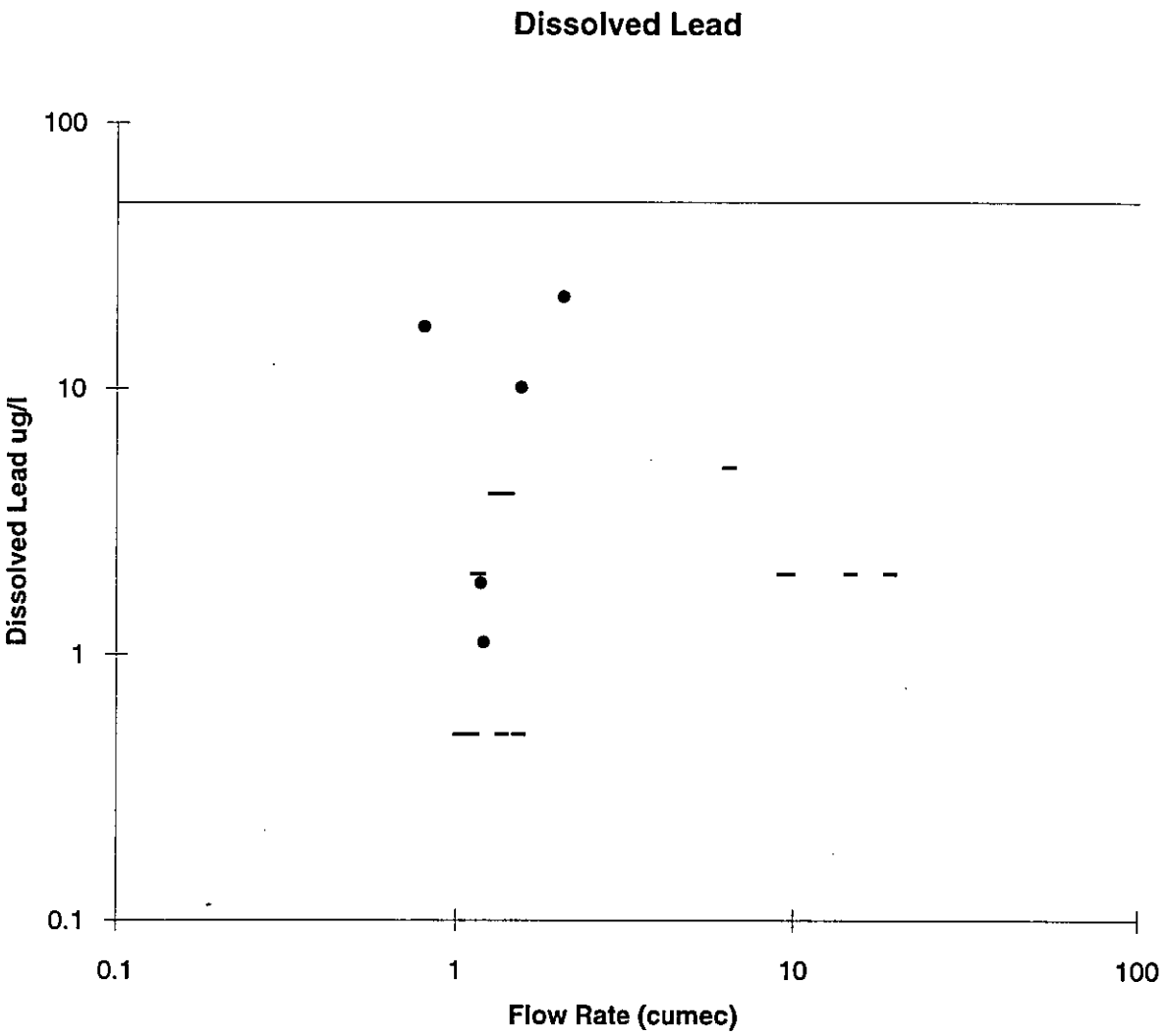
Dissolved Cadmium

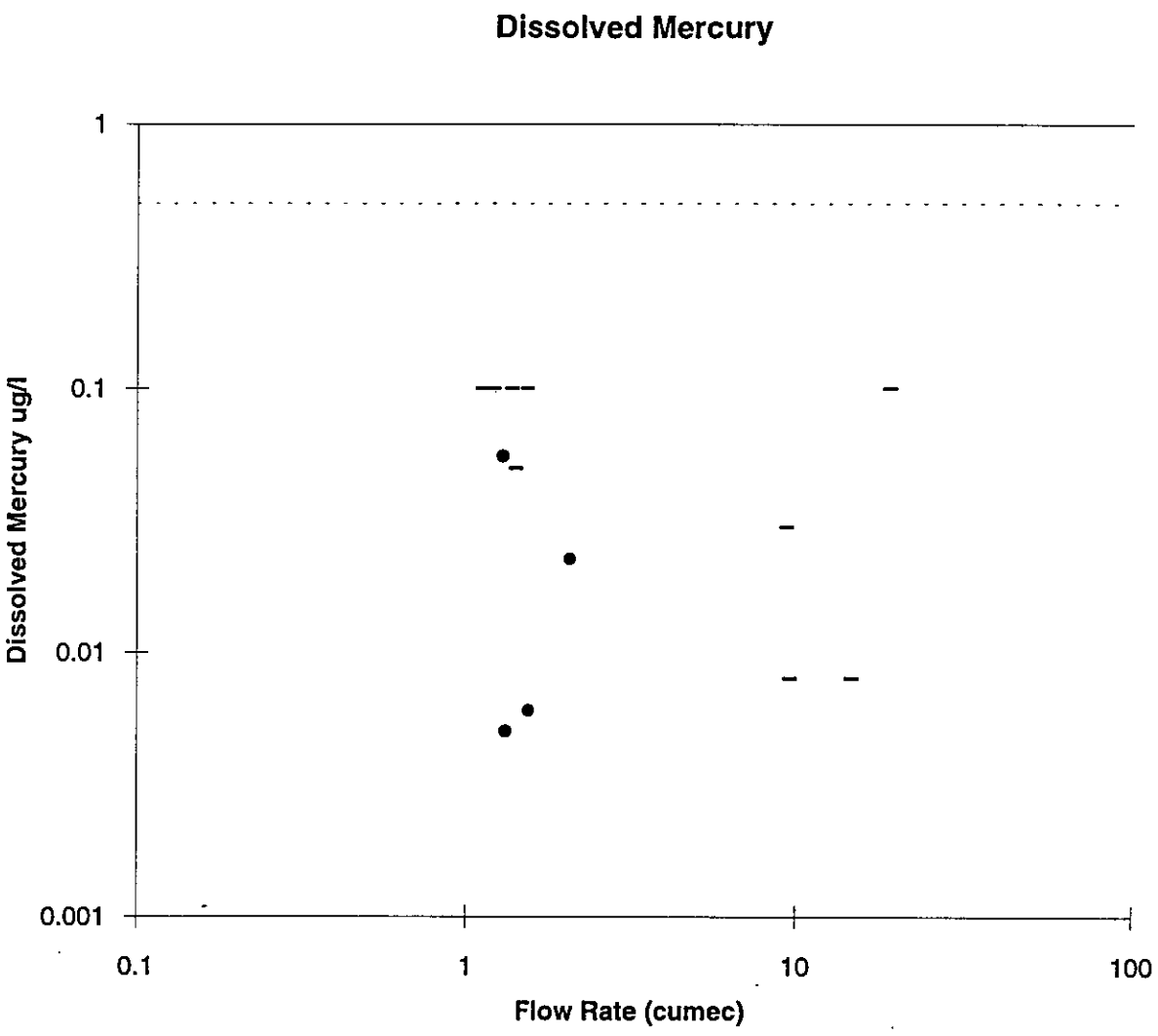


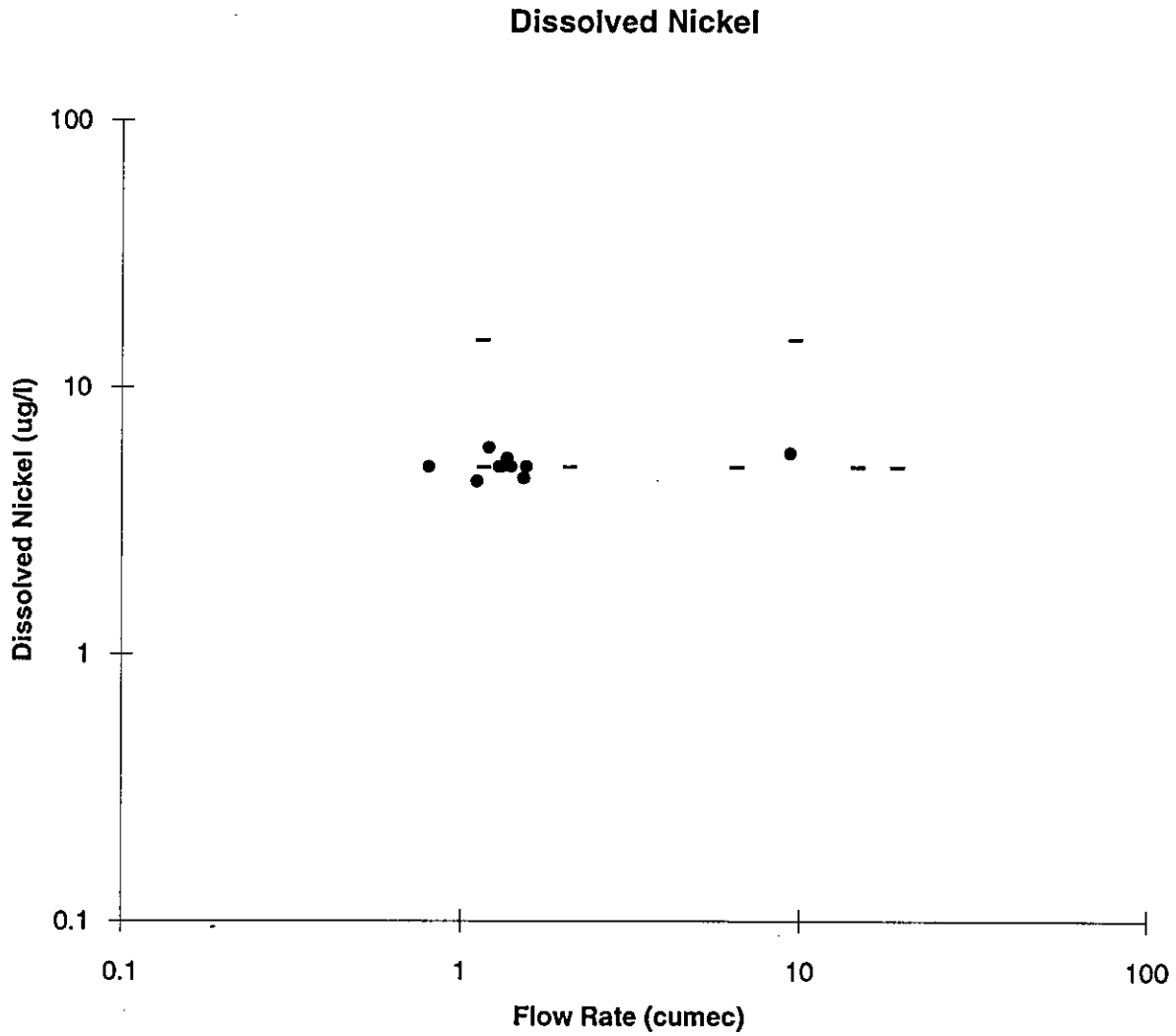

Dissolved Chromium
10
1
0.1
Dissolved Chromium (ug/l)
0.1
1
10
100
Flow Rate (cumec)

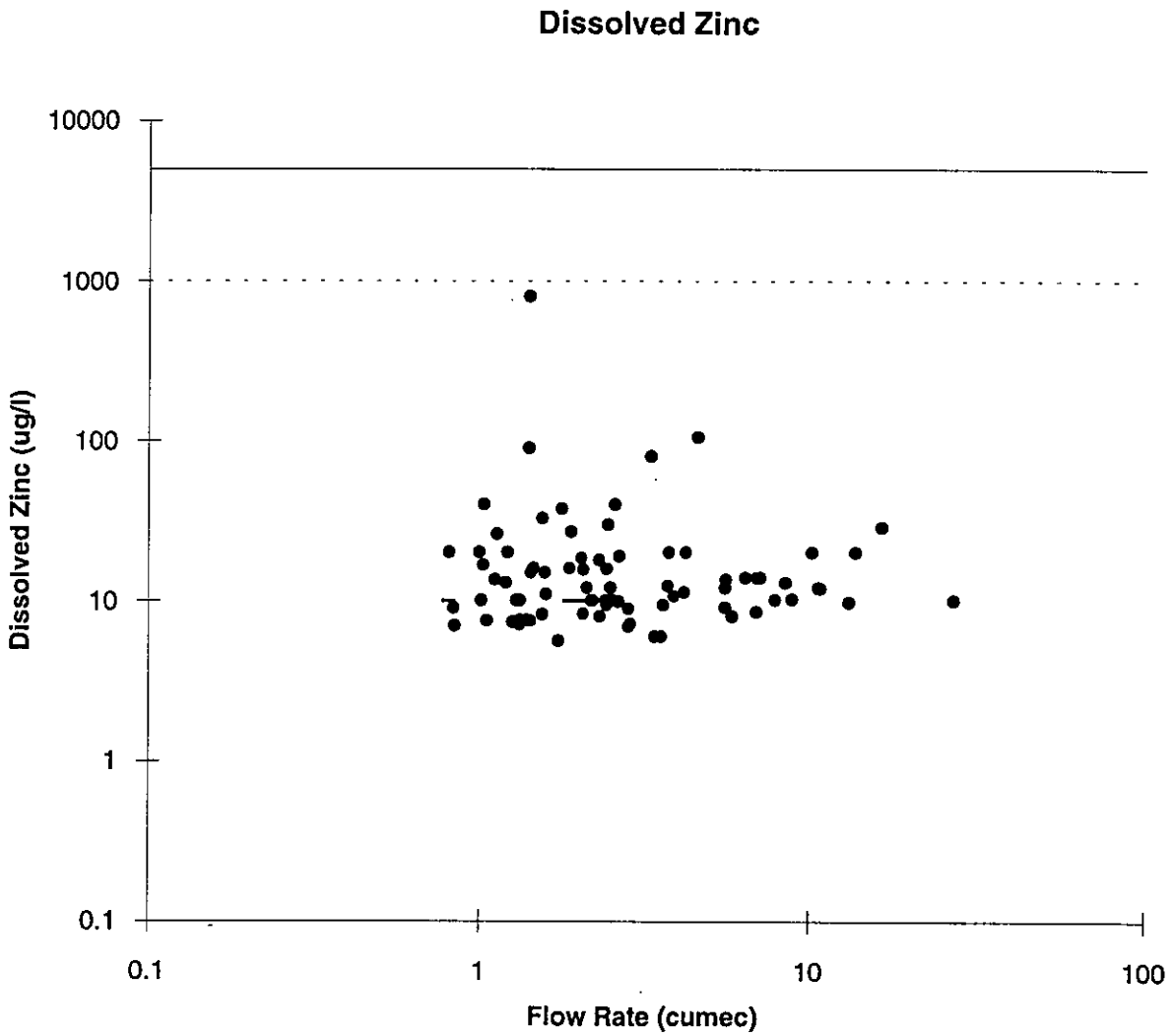

Dissolved Copper
1000
100
10
1
0.1
Dissolved Copper (ug/l)
0.1
1
10
100
Flow Rate (cumec)

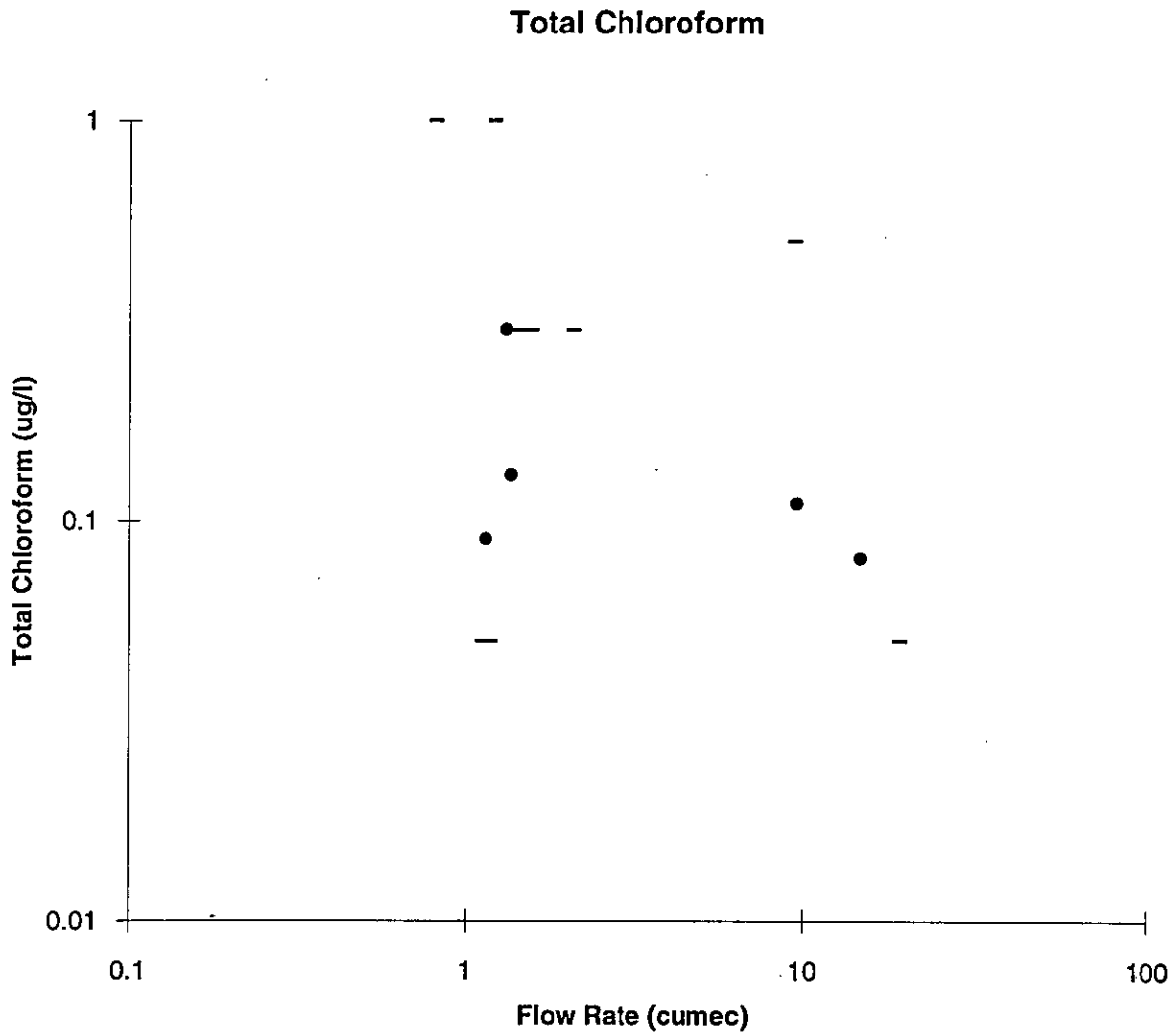

Dissolved Iron
1
0.1
0.01
Dissolved Iron (mg/l Fe)
0.1
1
10
100
Flow Rate (cumec)

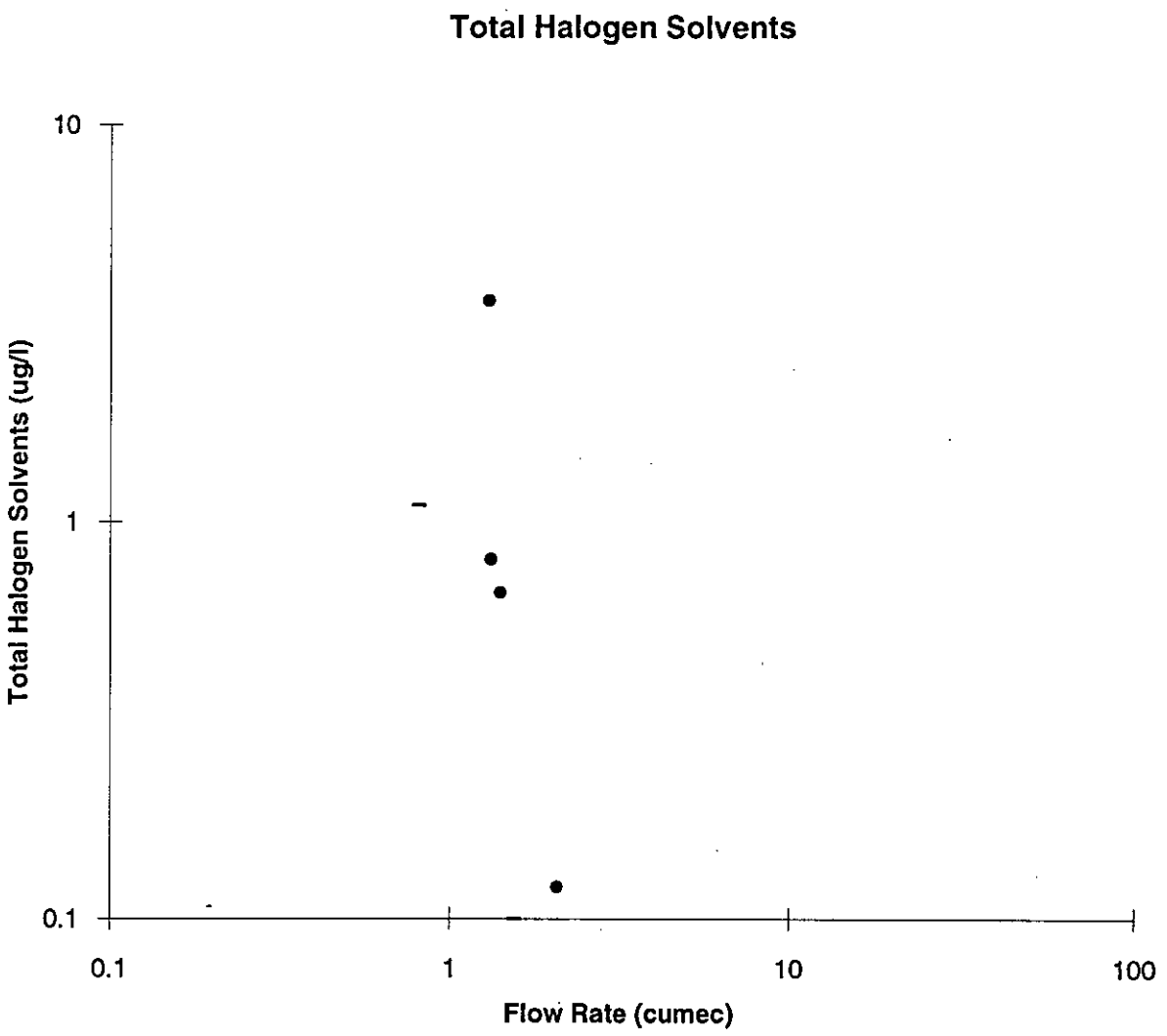

Dissolved Lead
100
10
1
0.1
Dissolved Lead ug/l
0.1
1
10
100
Flow Rate (cumec)

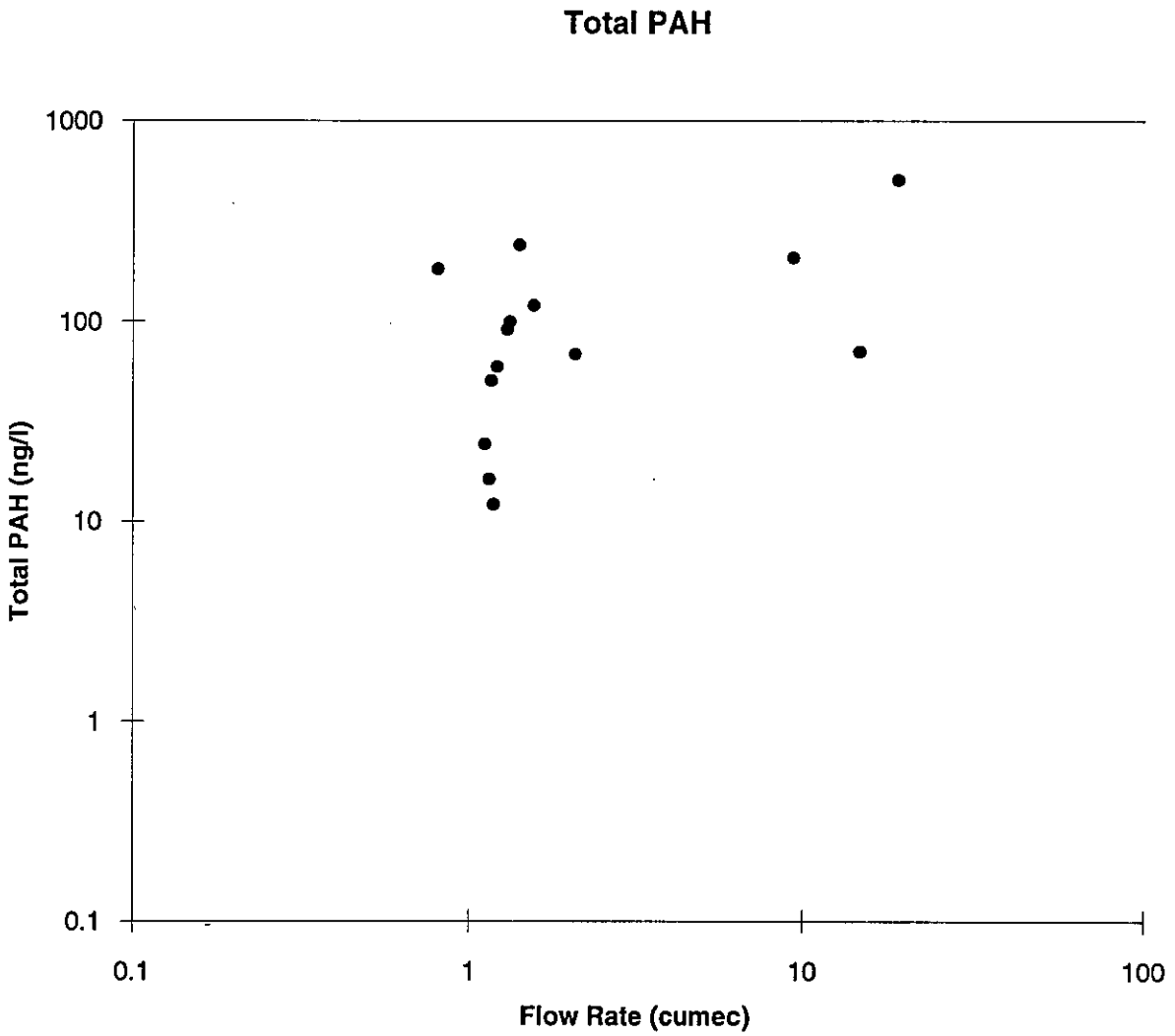

Dissolved Mercury
1
0.1
0.01
0.001
Dissolved Mercury ug/l
0.1
1
10
100
Flow Rate (cumec)


Dissolved Nickel
100
10
1
0.1
Dissolved Nickel (ug/l)
0.1
1
10
100
Flow Rate (cumec)

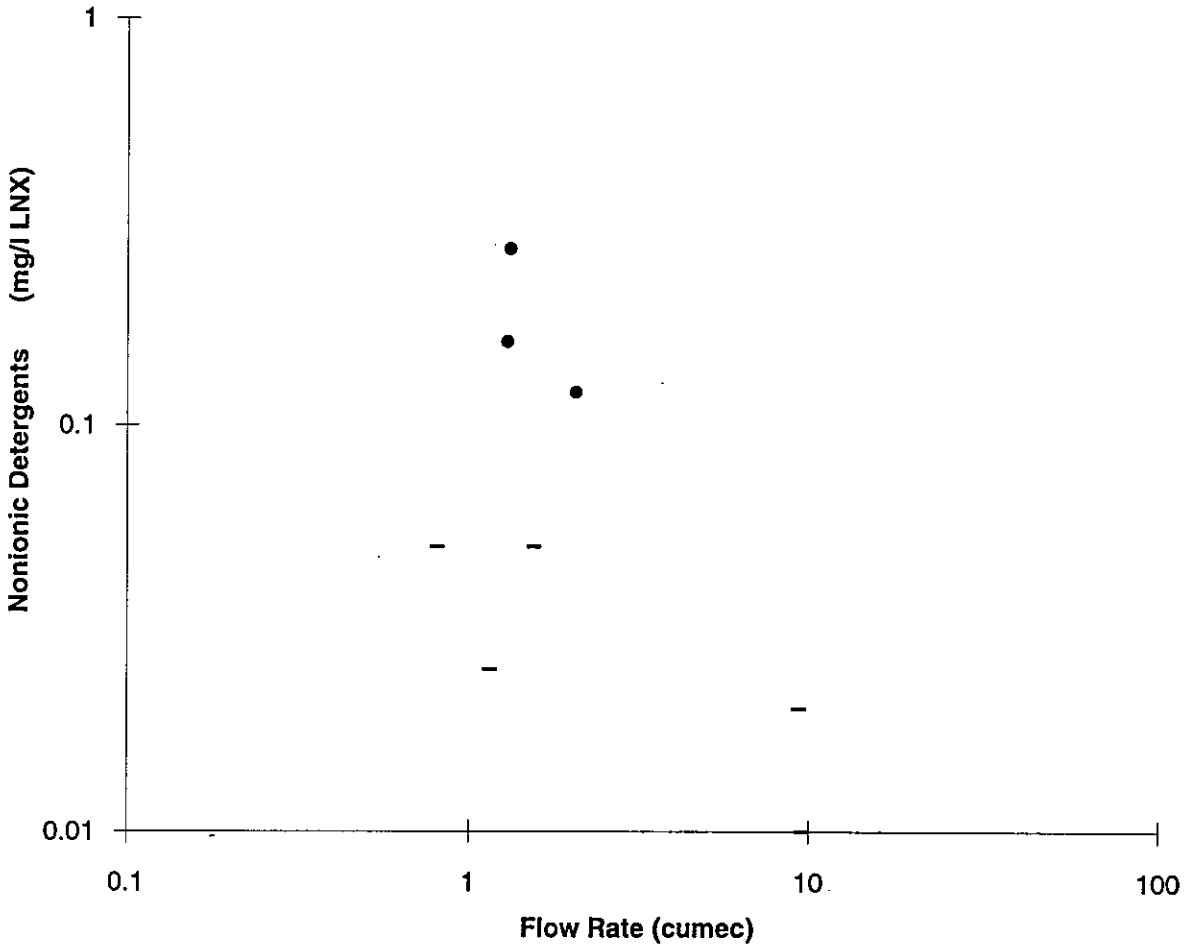

Dissolved Zinc
10000
1000
100
10
1
0.1
Dissolved Zinc (ug/l)
0.1
1
10
100
Flow Rate (cumec)


Total Chloroform
Total Chloroform (ug/l)
1
0.1
0.01
0.1
1
10
100
Flow Rate (cumec)

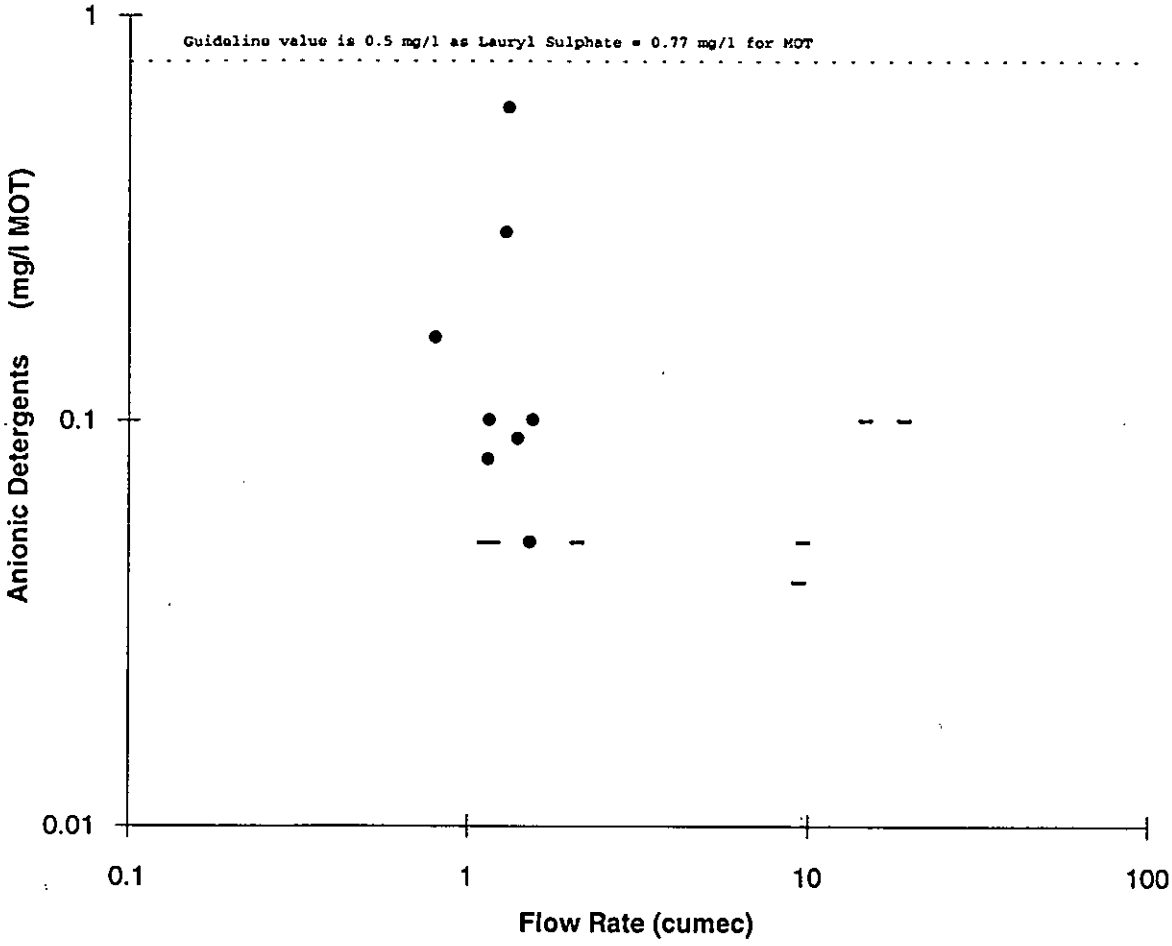

Total Halogen Solvents
10
1
0.1
Total Halogen Solvents (ug/l)
0.1
1
10
100
Flow Rate (cumec)

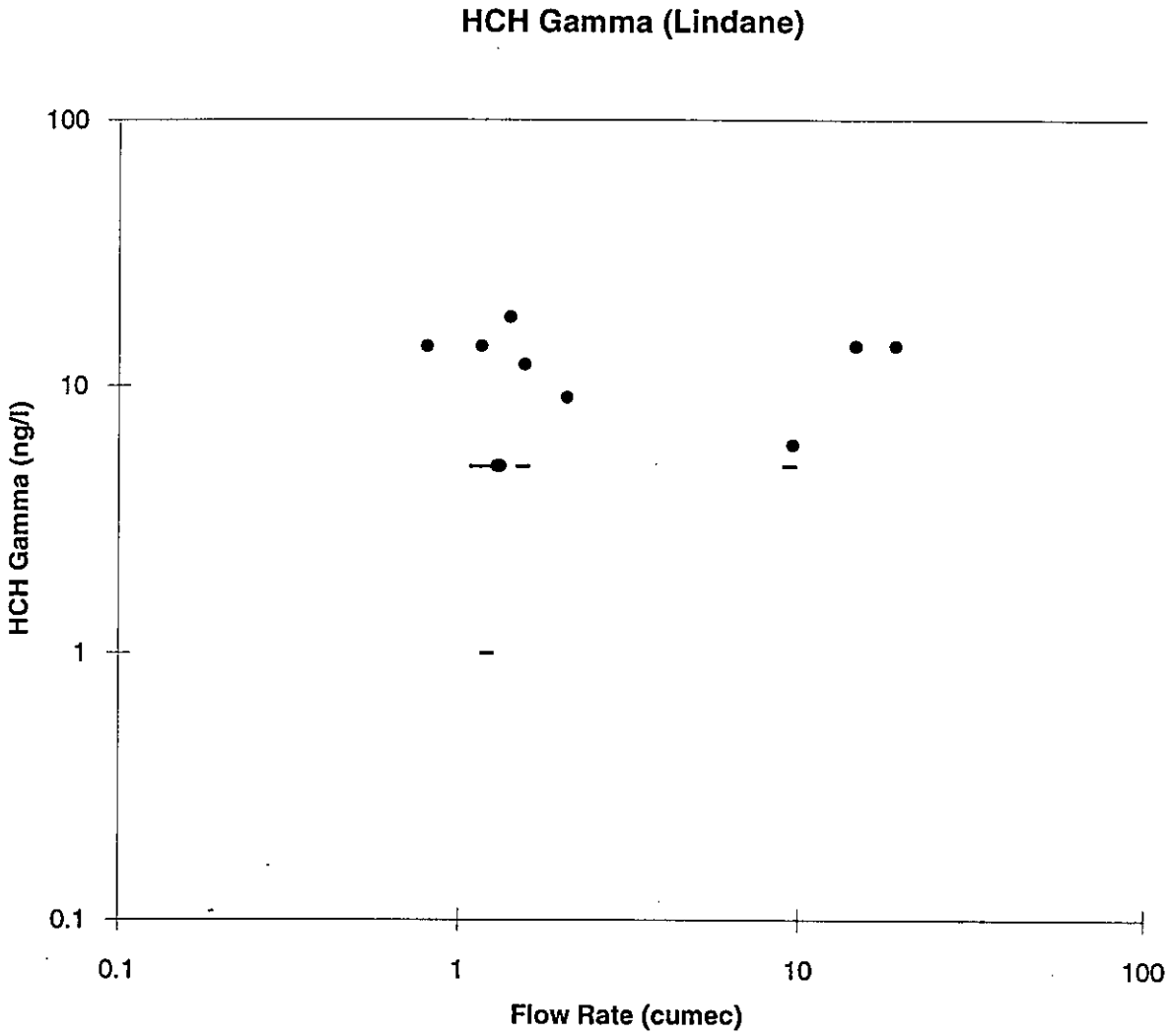

Total PAH
1000
100
10
1
0.1
Total PAH (ng/l)
0.1
1
10
100
Flow Rate (cumec)

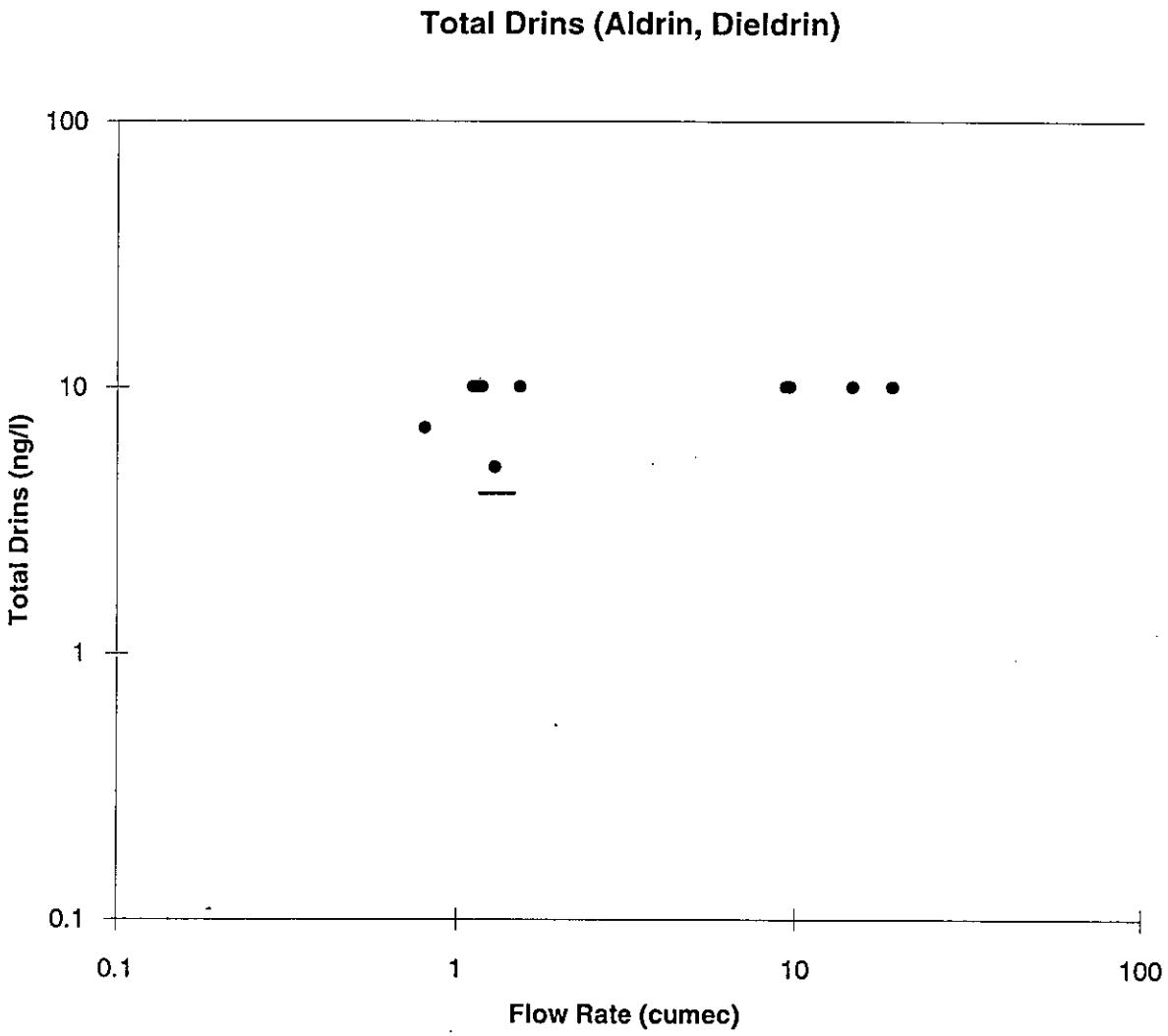
Nonionic Detergents

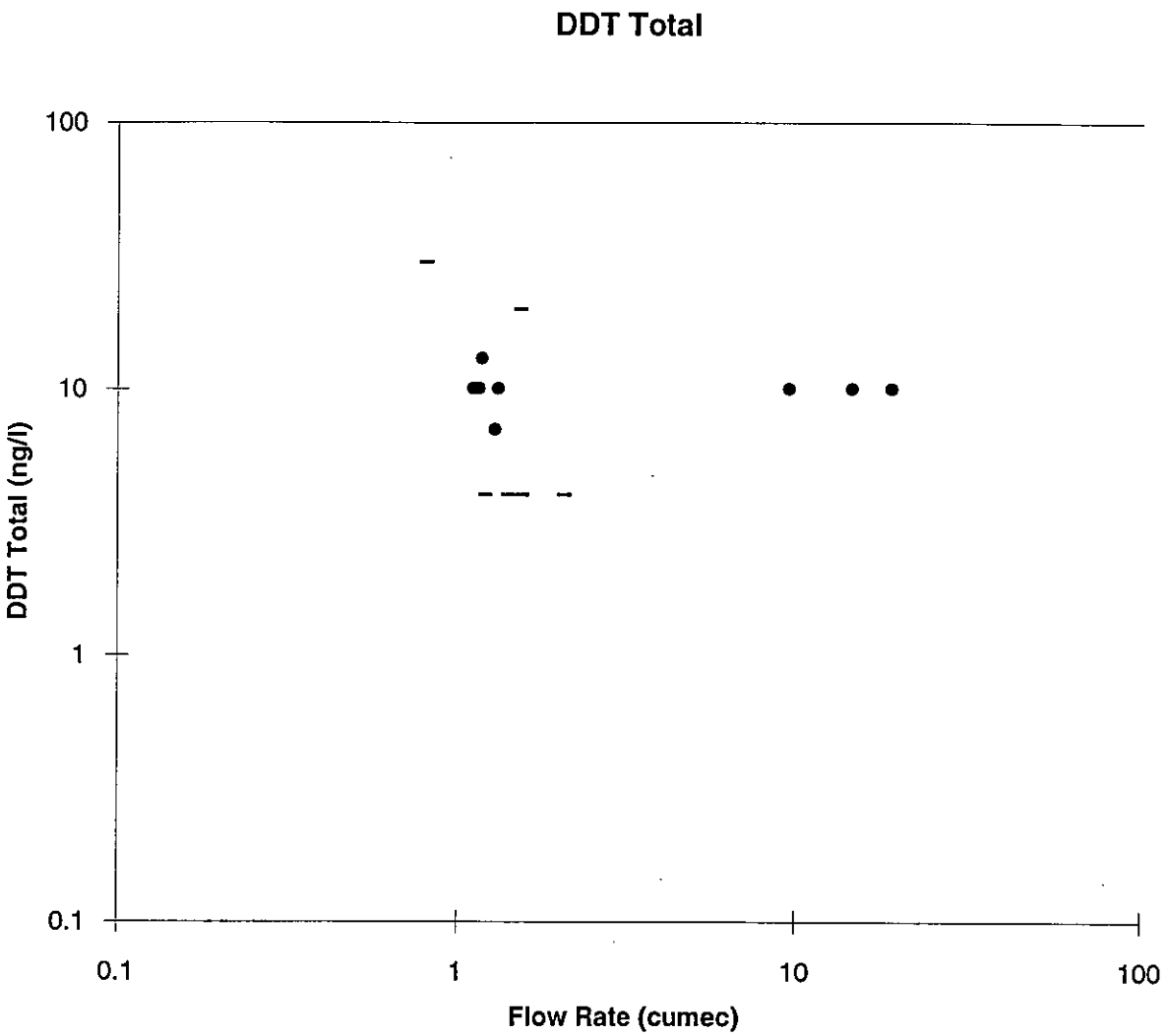


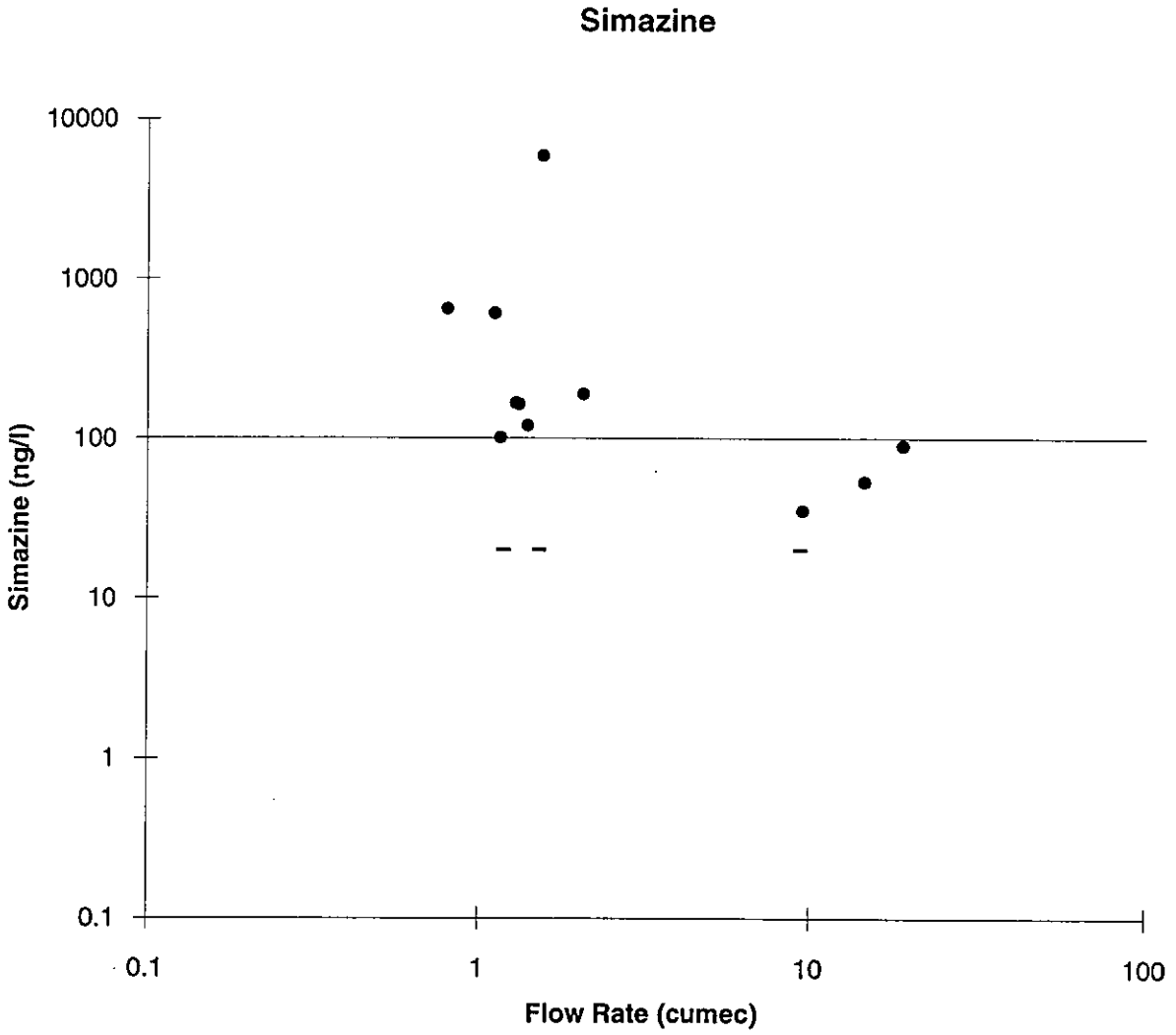
Anionic Detergents




HCH Gamma (Lindane)
100
10
1
0.1
HCH Gamma (ng/l)
0.1
1
10
100
Flow Rate (cumec)


Total Drins (Aldrin, Dieldrin)
100
10
1
0.1
Total Drins (ng/l)
0.1
1
10
100
Flow Rate (cumec)


DDT Total
100
10
1
0.1
DDT Total (ng/l)
0.1
1
10
100
Flow Rate (cumec)


Simazine
10000
1000
100
10
1
0.1
Simazine (ng/l)
0.1
1
10
100
Flow Rate (cumec)

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